TWO SIMPLE ZENER-DIODE TESTERS

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ProService Review
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Nocturnal Flame
Solar-powered night light is controlled by a PIC

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Synchros, Selsyns, And Accelerometers

Plug-In AC Power Supplies
How you can put them to work in your projects

CEA's Gary Shapiro
Discusses the future of Digital Electronics

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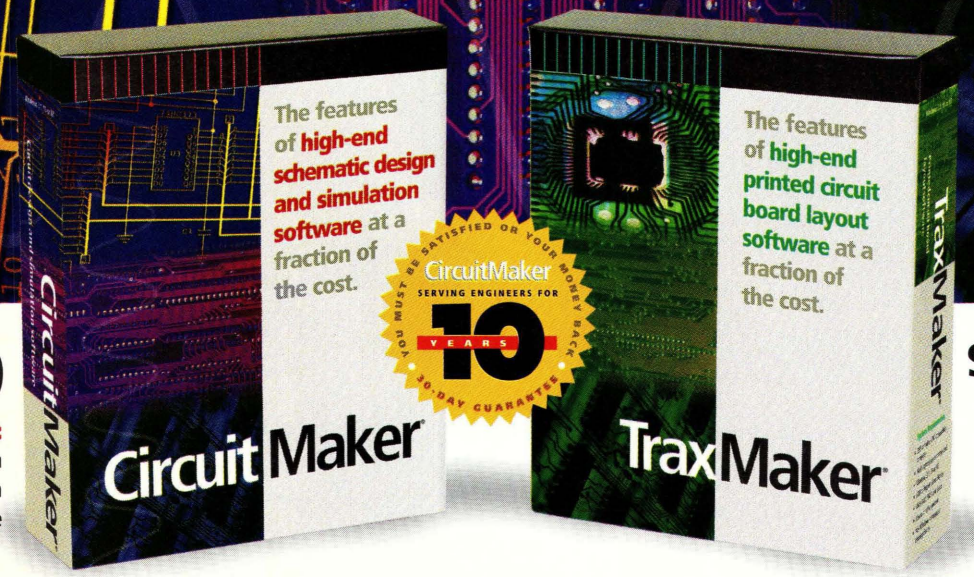
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CIRCLE 133 ON FREE INFORMATION CARD

Electronics Now

May 2000, Vol. 1, No. 5

Popular Electronics®

Poptronics®

THE MAGAZINE FOR THE HANDS-ON ELECTRONICS ACTIVIST!

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Editorial

E-Mail – The Good, The Bad, and The Ugly

E-mail is a wonderful invention. It makes it possible for all of us to get our written messages into the intended receiver's mailbox in moments. That's good!

It makes it possible to send off a message that can easily be delivered to the wrong person. Just one wrong stroke on the keyboard is what it takes. That's bad!

It opens our computers up to destructive viruses, seriously distasteful messages, and a real load of unwanted and unsolicited junk. That's ugly!

Overall, however, even though my electronic mailboxes are normally filled with hundreds of messages every day, I would not want to do without it. In fact, on those occasions that I am traveling, I can't wait to get at a computer at my next stop—and that means just about anywhere I can plug in the modem in my laptop.

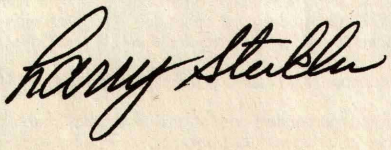
Looking over the variety of mail I receive, I can break it down into some four major categories—personal mail, mail from readers, business mail, and junk mail. Now that personal mail is important—it keeps me in touch with friends and family. That reader mail is also important, even when it brings me news of an error in an article in this magazine. The business mail is also important—news of new products, press conferences, events to keep tabs on, news, and financial news. The junk mail; well, that is another story altogether.

I know I can avoid junk mail simply by setting up a filter on my mailbox. But some junk mail isn't junk, and the title lines don't always help. As a result I open every e-mail sent to me (I NEVER open an attachment unless I KNOW where it came from. And even then, I will save attachments that I decide I do want to see onto a floppy disc). I also answer almost every e-mail I receive—the ones that are not junk mail. Please don't test me on that last statement. If you all decide to write, I won't have the time to respond. The 100 to 150 missives I currently receive each day is about all I can handle.

The biggest downside to e-mail is that there is no way to deliver it to someone who does not have an e-mail address and a way to retrieve their mail. If we were street people without an address, we could have our mail sent to us care of general delivery at the local post office and simply pick it up—at no cost to us. Unfortunately, we can't do that with e-mail. I'm kind of glad that I am not involved in delivering mail for the Post Office. It is only a matter of time before that shrinking business shrinks away. But for now, there is something that the Post Office can do for me. It can take my e-mail letter, send it electronically to a Post Office near you, print it out, put it into an envelope and deliver it to you, THE NEXT DAY, for the regular cost of a First Class Letter—33-cents. That would solve my problem of reaching people who do not yet have an e-mail address. Maybe, if the Post Office doesn't want to do this, there will be some private organization that will. Of course, they will have to charge more, 33-cents plus a handling fee; maybe $1, a letter, total.

The way it might work is that you would send the e-mail to my company, E-Mail Overnight, Inc. Your e-mail contains your message and the regular mail address of the person it is intended to reach. I bill your account or credit card for $1. I forward your e-mail to my agent in the city the letter is addressed to. That agent prints out the letter, places it in an envelope, puts a 33-cent stamp on it, and gets it to the local Post Office the same day. The following day it is delivered. That's certainly faster than the two, three, or four days it now takes an interstate letter to get delivered.

Now it's your turn. Tell me what you think of e-mail, how you use it, why you love it, why you hate it. Send your comments to me at *lsteckler@gernsback.com.*



Larry Steckler, EHF/CET
Editor-In-Chief

LETTERS

How About an Article on...

I want to create an FM transmitter/receiver pair for voice communications. The problem that I am having is that I cannot find any helpful hints or articles about FM receivers in any of your magazines. Any suggestions?

Why is that? I know that if you wanted to make an FM transmitter, you could use an FM receiver to do the receiving, but what if you want to use frequencies outside of the normal FM radio bands? Many of my friends who are electronic hobbyists are asking the same questions.

FRANK CHIRICO
via e-mail

It Should Do What I'm Thinking, Not What I'm Typing

In the "Net Watch" column that appeared in the March 2000 issue, you mentioned that browsers no longer require the *http://* to be typed at the beginning of a Web site address.

I have a copy of Netscape 1.0n (the .exe is only 800k in size!). Even that early browser will let you leave off the protocol ID.

JOSH
via e-mail

[A good point. I have a "shell" account on a Unix-based mainframe that supplies the text-based Lynx browser for Web access; that software requires the http:// prefix. Readers, what examples of Web browsers are out there that don't (if old) or do (if modern) need the full URL in the address box? Only full versions (not betas, alphas, or even "first clean compiles" that didn't have the feature activated yet during code testing) need be reported.—Editor]

Shame On You, Gordon...

In the March 2000 issue of **Poptronics**, there's a mistake in Fig. 5 of the "Robotics Workshop" column on page 66: The flyback diode is in the wrong place!

It should be across the motor coil.

JAMES PLUMMER
via e-mail

[You're absolutely right. The original artwork sent to the editorial office got a bit garbled by the fax machine. The motor coil looked like a resistor compounded by an ambiguous "To Motor Coil" label. If you remove the unlabeled resistor and put the motor coil in its place, everything should make proper sense.—Editor.]

...For Doing A Good Job.

I just received the March 2000 issue of **Poptronics**. I was very excited about Mr. McComb's "Robotics Workshop" column on using the OOPIC. It is just what I was looking for.

My high school class has built a robot using the Basic Stamp [controller] and want to do the same with the OOPIC. This article will surely do the job for us. We can't wait to get started.

Please convey my appreciation to Mr. McComb for providing the information we needed.

JACK MCINTOSH
Umitilla, OR

[OK, so we'll just waggle a finger at him!—Editor.]

...And The Same Goes For Mike!

In the December 1999 issue of **Electronics Now**, Michael Covington printed some information that I supplied to him concerning sources for electronic organ parts and manuals. An error was made in the ZIP code for Keyboard Systems of Salt Lake City; it should be 84121. Also, the new area code and phone number for Morelock's Organ Parts is 662-462-7611.

For finding parts or manuals on the Internet, the best source that I've found is MITA (the *M*usical *I*nstrument *T*echnicians *A*ssociation) at *www.mitatech.com*. They have listings for every organ that I've heard of, as well as quite a few that I haven't!

BILL STILES, CET
Hillsboro, MO

I've subscribed to **Radio-Electronics** and **Electronics Now** for over 15 years. This note started to be much longer but I'll cut to the point—Michael Covington's "PIC Assembly Language for the Complete Beginner" hit the target. I've built many kits, but feared "firmware." I won't go back. Nice job!

KEN DEKEN
Cleveland, OH P

KEEP IN TOUCH

We appreciate letters from our readers. Comments, suggestions, questions, bouquets, or brickbats ... we want to hear from you and find out what you like and what you dislike. If there are projects you want to see or articles you want to submit—we want to know about them. And now there are more ways than ever to contact us at **Poptronics**.

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Eight-Channel Home-Theater Receiver

Want to go a step beyond Dolby Digital's 5.1-channel surround sound? The *RX-V1* digital home-theater receiver ($3199 in black, $3299 in amber/champagne finish) from Yamaha is an eight-channel unit that adds two front-effects speakers to the conventional surround array. It delivers 100 watts to each of the six full-range channels (front and rear left, center, and right) required by the latest Dolby and DTS surround formats, including the 6.1-channel DTS-ES. Yamaha's front-effects channels receive 35 watts each. Total power for the eight-channel amplifier is over 700 watts rms.

For times when all that power might overwhelm the rest of the family, the RX-V1 provides Silent Cinema headphones, which use new technology and perceptual tools to achieve the effect of multiple-channel surround. Virtual Cinema DSP allows listeners to enjoy the effect of multiple-speaker surround without using the surround speakers. Audio purists will appreciate the Processor Direct switch, which enables the signal to bypass all control circuits.

The AM/FM tuner allows as many as 40 stations to be preset and arranged in groups for easy selection. A back-panel RS-232C port provides sophisticated interactive remote control and enables connection of custom-installation control systems. Zone-two outputs provide multi-room capability. The receiver offers 13 analog and seven digital inputs. All A/V inputs are equipped with S-Video terminals, and two independent video outputs allow the RX-V1 to be connected to both a TV and a projection system. For future external decoders, the RX-V1 is equipped with six-channel analog inputs.

Yamaha Corporation of America, 6660 Orangethorpe Ave., Buena Park, CA 90620; *www.yamaha.com.*

CIRCLE 50 ON FREE INFORMATION CARD

DVD Lifestyle System

Once you become accustomed to DVD, it's hard to go back to VHS. Sony offers a simple solution for adding DVD to a bedroom, vacation home, apartment, or college dorm room. The *DAV-S300 DVD Dream System* ($600) incorporates a full 5.1-channel amplifier with Dolby Digital and DTS decoding, a DVD/CD player, and an AM/FM receiver in one integrated unit. The amp provides 180 watts of total system power to the included speakers: subwoofer, center channel, front left and right, and rear left and right. Color-coded speaker connectors simplify setup, and the pre-programmed A/V remote control offers a one-touch play feature.

Sony Corporation of America, 1 Sony Drive, Park Ridge, NJ 07658-8002; 800-222-SONY; *www.sony.com.*

CIRCLE 51 ON FREE INFORMATION CARD

Scanning in a Snap

While scanners have come down in price to the point where people shop for them almost as they would for a mouse, it's important to remember that you do still get what you pay for. Consider shying away from $30 or $50 units and opting for a feature-rich, high-quality *SnapScan Touch* ($129, MSRP) from Agfa. This sleek USB peripheral can make importing paper-based data and images a ... well, a snap. And, it works on both PCs and Macs.

Forget about loading applications to use the SnapScan. Its four programmable buttons let you scan documents and images directly into e-mail, fax, word-processing, or other applications with one easy press. Thanks to the unit's 36-bit color depth, it can realistically reproduce over 68 billion colors, doing so at an optical resolution of 600 × 1200.

By the way, those artists who've bought a colorful, rather than beige, computer will be happy to know the SnapScan comes with seven different-colored handles. Match your PC or Mac or just your mood.

Agfa Corp., 200 Ballardvale St., Wilmington, MA 01877; 888-281-2302; *www.agfa.com.*

CIRCLE 52 ON FREE INFORMATION CARD

Improve Recognition

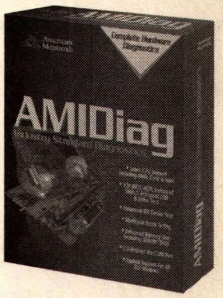
No matter what voice-recognition software you buy, chances are that you will get poor results if you try using an ordinary microphone. A truly noise-free environment is hard to come by these days, and your software will be picking up more data than it knows how to handle. Eliminate the noise before it enters your system with Andrea Electronics' *QuietWare 1000 ANC* ($124.95 direct from Andrea; $169 MSRP). Using Active Noise Cancellation technology, the microphone in this headset will reduce up to 6 dB/octave, making your software's job a lot easier.

But there's much more to this headset. Realizing you might actually try listening to audio from your computer in a noisy environment, too, the engineers at Andrea added Active Noise Reduction to the earphones. This additional feature can cut down the hum of a train or plane, as well as the chatter of an open office area.

Andrea Electronics, 45 Melville Park Rd., Melville, NY 11747; 800-442-7787; *www.andrea electronics.com.*

CIRCLE 53 ON FREE INFORMATION CARD

Diagnostics for All



Real techies don't always have to get their hands dirty to find out what's wrong with a PC. American Megatrends *AMIDiag 6.0* ($99, MSRP) is a complete, system-level diagnostics package that does it all through software.

The easy-to-navigate suite accurately tests hard drives, memory, I/O ports, sound cards, network connections, processors, and more. As for its CPU compatibility, the software recognizes the latest Intel and AMD chips, like Pentium III and Athlon; and it can even test the cache memory residing inside these processors. It's a program no PC troubleshooting kit should be without.

American Megatrends, Inc., 6145-F Northbelt Parkway, Norcross, GA 30071; 800-828-9264; *www.ami.com.*

CIRCLE 54 ON FREE INFORMATION CARD

iPhone the World

You're going to love this—trust us. If you're thinking of adding a telephone or replacing one, forget about traditional offerings. With the *iPhone 2050* ($399 MSRP) from InfoGear, you can do a whole lot more than just chat it up with friends. This is a complete Internet appliance that brings the online world to just about any room you'd like, while leaving your PC on its desk.

The iPhone's crisp, flip-up LCD screen, though monochrome, lets you experience most any Web site without eyestrain. Because it is touch sensitive, the screen makes it possible to tap on desired links with the included stylus. For writing e-mail, entering URLs, and other typing, slide out the surprisingly responsive keyboard and crank away.

All in one, it's everything you need to add a Web terminal to your home. Even temperamental press people love this gadget—the Consumer Electronics Show pressroom featured a dozen iPhones, and we heard no complaints.

InfoGear Technology Corp., 2055 Woodside Road, Suite 200, Redwood City, CA 94061; 650-568-2909; *www.infogear.com.*

CIRCLE 55 ON FREE INFORMATION CARD

HDTV-Ready Direct-View TV

The *SharpVision 34N-WF5H* HDTV-ready TV ($4999) from Sharp features a 34-inch (diagonal), 16:9 aspect ratio, "Pure Flat" picture tube. The HDTV-ready set uses a proprietary Digital Double Format Converter (DDFC) that allows standard video to be viewed at 480p or 1080i. DDFC detects 3:2 pull-down of film-originated material and provides a smooth image and significant flicker reduction from the original video source. A 10-bit 3D Y/C digital comb filter is said to filter out artifacts inherent in broadcast signals at a rate four times better than conventional filters.

Two tuners allow viewers to watch two programs side by side as well as enabling picture-in-picture. Four viewing modes include a 4:3 display with sidebars. Four color-temperature presets allow the warmth or coolness to be adjusted according to the viewer's personal preference. The 34N-WF5H can receive 1080i, 480p, or 480i signals at its five inputs. Front-panel inputs include an S-Video jack and a set of AV/composite jacks. Rear-panel jacks include dual S-Video, RGB, dual component, and A/V composite inputs.

Sharp Electronics Corp., Sharp Plaza, Mahwah, NJ 70430; 800-DTV-SHARP; *www.sharp-usa.com.*

CIRCLE 56 ON FREE INFORMATION CARD

GIZMO®

Progressive Scan DVD Player

Every day, most of us are exposed to two different types of electronic images. Traditional NTSC analog television separates the odd- and even-numbered lines of a picture and then creates an image using interlaced scanning in which the two fields are transmitted consecutively and superimposed. VGA computer monitors, on the other hand, use progressive scanning to simultaneously "paint" all the horizontal scan lines on the screen, which results in a smoother picture with a higher apparent resolution.

The *PDV-2001 Progressive 480p* DVD player ($1200) from Proton uses built-in progressive scan circuitry to process any 480i (interlaced) video source (DVD, DSS, laserDisc, VHS) to 480p DTV-class resolution. According to Proton, it uses an advanced, reversed "3-2 pull down" algorithm to restore movies to their original theater quality. The circuitry doubles the scanning lines to provide greater detail and truer color rendition in a digitally scaled 480p image that is artifact-free. The PDV-2001 has an auto-detect and auto-switch film/video mode. It offers color-difference output (Y/B-Y/R-Y), mapping the DVD (YC_rC_b) format. Dolby Digital/DTS-compatible digital outputs, one coax and one optical, are provided.

Proton Corp., 13855 Struickman Road, Cerritos, CA 90703-1031; 562-404-2222; *www.proton-usa.com.*

CIRCLE 57 ON FREE INFORMATION CARD

Desktop Stereo

What separates an "executive desktop stereo" from a plain-old bookshelf system? Designed for use in the office, desktop stereos generally combine a no-nonsense, visually appealing style with a small footprint and dramatic sound. The *FS-SD9* ($450) from the company that arguably created the category, JVC, certainly fits the bill. The Executive Desk Stereo combines a pair of speakers in sleek, cherrywood-finished cylindrical enclosures with an amplifier/CD player/tuner that has a champagne-gold finish and a matching amber LCD display.

Cylindrical speaker enclosures are said to reduce standing waves, creating smooth frequency response and natural sound spread. Both rigid and lightweight, the full-range, bass-reflex Kevlar speakers boast JVC's Active Hyper-Bass Super PRO. Pumping 38 watts of power (19 × 2), the amplifier provides both an optical digital output and a line-level subwoofer output. The digital tuner has 30 FM and 15 AM station preset memories and an auto-reset feature.

JVC Company of America, 1700 Valley Road, Wayne, NJ 07470; 973-315-5011; *www.jvc.com.*

CIRCLE 58 ON FREE INFORMATION CARD

MP3 and Images to Go?

A trend we're happy to see in the world of mobile electronics is that of combining multiple devices into one form factor. Think about it—who wants to carry around ten gizmos at once? But if there's one you'd like to carry, say a portable music player, wouldn't it be great to take advantage of the space it occupies by incorporating some other features? The folks at Samsung thought so and have come up with the brilliant *Photo YEPP* ($399, MSRP). While its name might not make it clear, the YEPP's an MP3 player and so much more.

First, as for its aural capabilities, the YEPP features a seven-mode equalizer with an interesting 3D audio setting that can enhance certain types of content. The initial base offering will come with a 32MB SmartMedia card good for an hour of CD-quality audio or two hours of voice recording (that's right, you can take compressed dictation on the go). You'll be able to swap cards to higher, 64MB versions when they're available, or just get a few extra 32s to carry around.

The real appeal in the Photo YEPP is what its 2-inch color LCD makes possible. You can view lyrics or photos of an artist while listening to a track or carry around any other type of text and digital images. The Photo YEPP can thereby not only hold addresses, phone numbers, and the like, but niceties like maps as well. Now that's a personal data assistant!

Samsung Electronics America, Inc., 105 Challenger Road, Ridgefield Park, NJ 07660; 201-229-4000; *www.samsungyepp.com.*

CIRCLE 59 ON FREE INFORMATION CARD

Gizmo is published by Gernsback Publications, Inc., 275-G Marcus Blvd., Hauppauge, NY 11788. Senior Writers: Christopher Scott, Teri Scaduto, and Selina Kyle. *Copyright 2000 by Gernsback Publications, Inc. Gizmo is a registered trademark. All rights reserved.*

TED NEEDLEMAN

Plastic to Plastic, The Final Chapter

In the April issue, I detailed the process of turning vinyl LPs into polycarbonate music CDs, including a few problems I encountered along the way. With more than 100 albums to "burn" as CDs, I haven't made all that much progress here in making the changeover, but I'm still working on it.

This time around, I'll detail the finishing touches. Of course, if you have just a few albums that you're transferring to CD, you could just write the titles on the disc with a special CD-R marking pen. You'll find them in the computer store, or you can use a standard marking pen. It just seems to me that if you are going to spend the time to make CDs from your older vinyl albums, then you should take some extra time and make the job look as well as sound good.

The easiest way to do this is to use an inexpensive CD label kit. With CD-R and CD-RW drives so popular, many vendors (including Avery and other label makers) have introduced stick-on round labels. Simply print what you want with your printer, peel off the backing, and place it on your CD-R/RW.

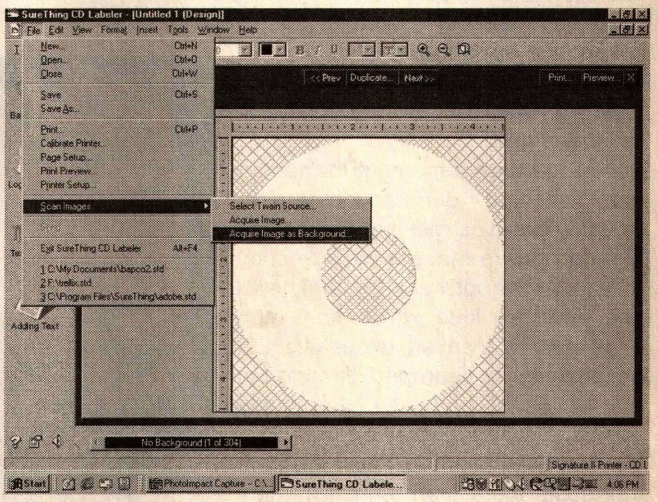

SureThing CD Labeler - [Untitled 1 (Design)]
File Edit View Format Insert Tools Window Help
Scan Images...
Select Twain Source...
Acquire Image...
Acquire Image as Background...
Exit SureThing CD Labeler Alt+F4
Adding Text
No Background (1 of 304)

Fig. 1. The SureThing Labeler makes it easy to scan an image directly for use on a label.

I've used most of the popular ones over the years, from Neato, CD-Stomper, Memorex, and Microvision Development. For the past year or so, I've settled on components from two of the popular vendors—Microvision Design's (MVD) *SureThing* labeler and Memorex's *CD Label* kit. Both vendors provide software for designing and printing the labels, and an applicator for correctly applying the label to the CD-R/RW.

My problem is that while I think Memorex's applicator is absolutely the best on the market, I feel the same way about Microvision Development's *SureThing* labeling software. So my suggestion is to buy the Memorex kit, then download the free version of *SureThing*. I think after you've used the download for a

Fig. 2. When SureThing launches your scanner's TWAIN driver, you select the portion of the image that you want to use.

VENDOR INFORMATION

Memtek Products, Inc.
1-100 Pioneer Blvd., Suite 110
Sante Fe Springs, CA 90670
800-636-8368
www.Memorex.com

Microvision Development, Inc.
2185 Faraday Ave.
Carlsbad, CA 92008
800-998-4555
www.surething.com

Primera Technology, Inc.
Two Carlson Parkway North
Plymouth, MN 55447-4446
800-797-2772
www.primeratechnology.com

Ulead Systems, Inc.
970 West 190th Street, Suite 520
Torrance, CA 90502
310-523-9393
www.ulead.com

while, you'll end up paying MVD for the retail version.

There are two reasons I really love *SureThing*. One is that it provides over 300 really good looking disc designs, much more than any similar product I've seen. Not only does it have loads of clip art, but you can easily churn out superior-looking CD labels as well as jewel-case inserts. With the paid-for version, you can make labels for floppy and Zip disks. The second reason is that *SureThing* lets you scan a CD disc or jewel case and use the scanned image as a background. This lets you print a label (or jewel-case insert) for your CD that looks exactly like the original.

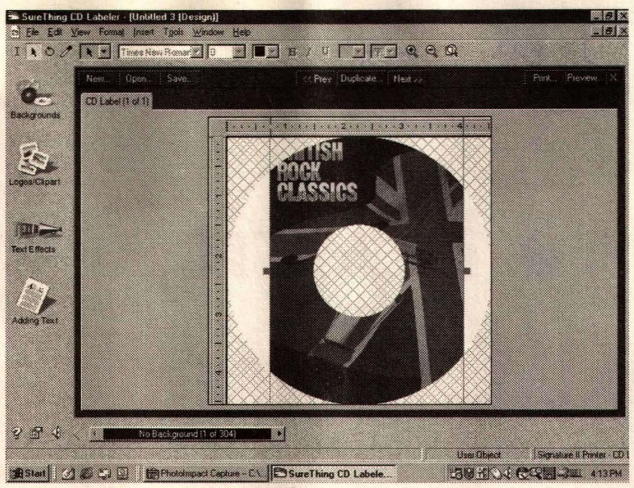


Fig. 3. Sometimes the scans don't produce a good fit.

Let me take a moment to make it very clear that I don't advocate piracy. I do, however, feel that purchasers have a right to make a backup copy of expensive software for their own use. With four kids, we've more than once had to toss an expensive CD because it was improperly inserted in the CD-ROM tray and was badly scratched when the tray closed. Now, the rule here is that any new program that costs more than ten bucks gets copied first and the copy, not the original, is used day-to-day. There are some CDs that are copy protected, but that's another column.

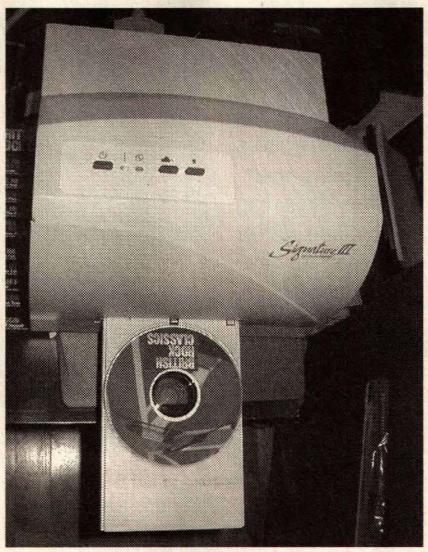


Fig. 4. The finished CD-R disc emerges from the Primera Signature III CD Printer.

To finish off my audio CDs, the first step was to decide what part of the cover to use for the disc. *SureThing* lets you activate the scanner's TWAIN driver directly from within the application, and place the scanned image on a blank disc template (see Fig. 1 and Fig. 2). This, however, doesn't always work out well (Fig. 3). In my case, no matter how I placed the scan, parts of the title got "eaten."

Fig. 5. Finding a segment of the album cover to use for the jewel case insert is a lot easier.

The answer in this particular case (and with many of the albums I've transferred so far) was to compose a disc face from two separate scans. The guitar painted like a British flag is a great background, and I scanned and placed it using *SureThing*. To get the title down to a size that would actually fit on the disc, I needed to scan it separately. While *SureThing* is terrific for putting together disc labels, it really isn't the best software to use as a scanner utility. For that I turned to Ulead System's *PhotoImpact 5*, which is generally the first graphics package I pull out. Using the Acquire feature, I scanned the title and saved it as a separate .BMP file. Opening *SureThing* again, I placed the title on the flag/guitar background, sized it, and was ready to print.

NOTHING LASTS FOREVER

SureThing does a great job with paper labels, but I was lucky enough to have the use of a Signature III CD printer from Primera Tech-nology. The Signature III is a specialized inkjet printer that can print directly on to specially surfaced CD-R blanks at up to 1200 dpi. These blanks are still rather expensive (a couple of bucks each) when purchased from Primera, but CompUSA sells a spindle of 30 discs for $30. The special surface takes the ink great; and the CD-R, which can be recorded at up to 8X, looks like it was professionally silk-screened.

Besides producing terrific-looking discs, the Signature III's print should last for decades. While the CD-Rs themselves are rated as having a life in excess of 30 years, I've never seen a paper label that claimed anywhere near that kind of life. And while it might seem silly to worry about how my audio CDs are going to look 10 years from now, I've already had some of the vinyl albums that I'm transferring for almost 40 years!

The downside is that the Signature III, at over $1500, is expensive. I certainly couldn't afford to buy one just to have great looking CD-Rs. Of course, if I was more industrious, I could cost justify one by producing custom CDs for wedding and other special occasion gifts. A neighborhood chocolate shops does a good business making up these types of "goodie bags," pay a lot of money (and charging its customers even more) for these special CDs.

A more likely scenario would be for a local computer club to purchase a

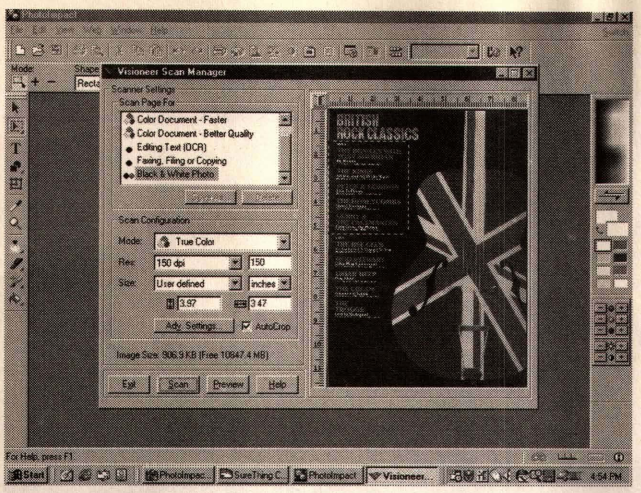


Fig. 6. PhotoImapct 5 was used to scan the track list from the album's rear cover.

Signature printer (the printer choice is for the previous Signature II model, but works perfectly with the Signature III). While the Signature III can print at up to 1200 x 600 resolution, I usually print my CD-Rs at the default 600-dpi setting; it's a lot quicker. The photograph in Fig. 4 shows the result of a couple of minutes' printing time.

The jewel case insert is even easier. In *SureThing*, I switched the label stock setting to jewel case insert, and scanned just the upper left corner of the record album cover (Fig. 5). No fancy printer was necessary for this part of the process, I printed the jewel case front and rear inserts on a standard Epson inkjet. For the rear insert, I again turned to *PhotoImpact 5* (Fig. 6) to pull off the track lists into separate .BMP files, which I placed in *Sure-Thing*, and then printed. In retrospect, it probably would have been easier to just type in the track list, rather than go through the scanning and placing process.

Fig. 7. Going from plastic (vinyl) to plastic (polycarbonate) gives you a backup that protects against damage.

Figure 7 is a photograph that shows the before and after. Now to get to the other 99 or so albums done. As always, I welcome your comments, suggestions, and questions at *tneedleman@aol.com*. P

Signature III for its members' use. A club with 100 members needs only to assess each member $10 to purchase the CD Printer for the club. In fact, charging non-members a modest premium to print CD discs for them would be a good way to recoup the purchase price.

SureThing directly supports the

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UVC2001 series

Integrated 2-axis Controller
EMC2M

Universal Controller
UVC2001 series

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Integrated Controller
EMC series

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- 5-phase stepping motor driver incorporated
- 2-/3-axis simultaneous control available. Easy multiple-axis control through RS-485 communications (up to 16 units)

URL = http://www2.dango.ne.jp/onomichi/inh/
E-mail = inh@orange.ocn.ne.jp

INH International Hanbai Co., Ltd
22-30 Kanda-cho, Onomichi, Hiroshima, 722-0016, Japan

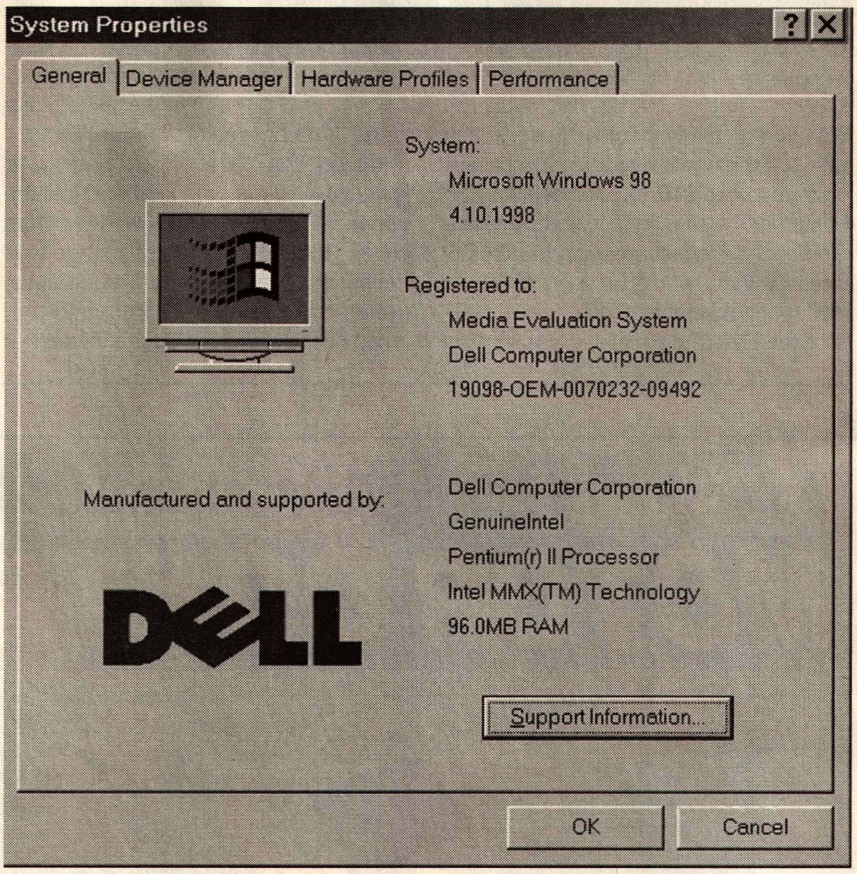
SELINA KYLE

Which Windows to Do?

The hype is likely still alive as you read these words, as is the confusion. Windows 2000—the sequel to 98, or is it Windows Millennium that holds that spot? And what's Win98 Second Edition?

You know, all that confusion.

You've sent us your questions about which Windows is which, and we've been listening. So, after answering countless e-mails, we figured we'd clarify the mess for all our readers, as well as lay the groundwork for some of the upgrades we have in store for the next few months in this column.



A quick check of your System dialog in Control Panel will let you know if you need to upgrade to Win98 SE. Chances are you do, and chances are you'll be glad when it's done.

MICROSOFT'S "BOO-BOO"

Perhaps you've come across this simple distinction before: Home computers run Windows 3.X or 9X, and networked business machines run Windows NT X. The "X" designations here refer to, of course, ever-changing version numbers: Windows 3.1 or 98, or NT 4.0, and so on. In short, Windows with a number or date right after it was pretty much the home user's version of the operating system, with the exception of small companies that find it easier to run the consumer OS, too. The large corporations prefer the security, stability, and easier manageability of NT.

Therefore, shopping for a new Microsoft operating system (we won't be touching on Linux and other options here) was always simple. With the advent of the 32-bit "dated" OS, Windows 95, consumers knew that their next option would also bear a date, and bear one it did: 98. Business Information Technology (IT) managers knew to purchase the next version of NT-after 4.X; the next major version was supposed to be the much-anticipated 5.0, also called the answer to every IT manager's dreams: The Holy Grail of network OSes.

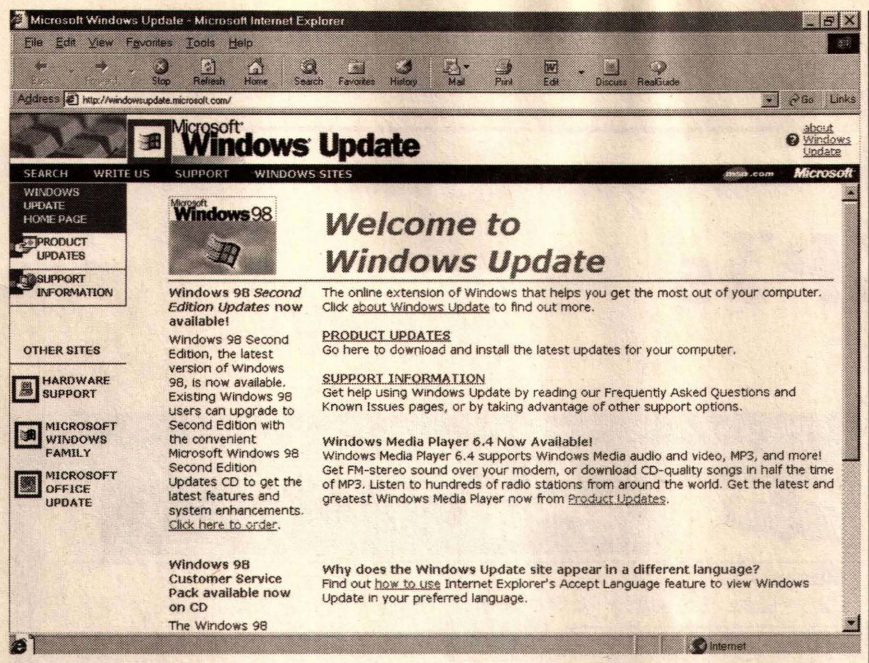
So where's NT 5.0? It's out, all right. Unfortunately, it's named Windows 2000!

That's where quite a bit of confusion has set in.

At the time of this writing, the OS of choice for home users is still Windows 98 (or the Second Edition of it, for reasons we'll get to). Unless you plan to run your machine within the infrastructure of Corporate America, the next new OS you'll likely be buying is Windows Millennium (ugh, we know, there's that dated-sounding word again).

What was Microsoft thinking calling the next version of NT Win2000? We'll probably never have an adequate answer to that question. When we tried to find out how they were planning to keep consumers from being totally puzzled, Microsoft press representatives told us that a sticker on the box would proclaim that the package was "based on NT technology."

Great. We're sure the Microsoft returns department will be hearing many nice comments about the power and prominence of this sticker. The


Microsoft Windows Update - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://windowsupdate.microsoft.com/
Microsoft Windows Update
about Windows Update
SEARCH WRITE US SUPPORT WINDOWS SITES
Microsoft
WINDOWS UPDATE HOME PAGE
PRODUCT UPDATES
SUPPORT INFORMATION
OTHER SITES
HARDWARE SUPPORT
MICROSOFT WINDOWS FAMILY
MICROSOFT OFFICE UPDATE
Windows 98
Welcome to Windows Update
Windows 98 Second Edition Updates now available!
Windows 98 Second Edition, the latest version of Windows 98, is now available. Existing Windows 98 users can upgrade to Second Edition with the convenient Microsoft Windows 98 Second Edition Updates CD to get the latest features and system enhancements. Click here to order.
The online extension of Windows that helps you get the most out of your computer. Click about Windows Update to find out more.
PRODUCT UPDATES
Go here to download and install the latest updates for your computer.
SUPPORT INFORMATION
Get help using Windows Update by reading our Frequently Asked Questions and Known Issues pages, or by taking advantage of other support options.
Windows Media Player 6.4 Now Available!
Windows Media Player 6.4 supports Windows Media audio and video, MP3, and more! Get FM-stereo sound over your modem, or download CD-quality songs in half the time of MP3. Listen to hundreds of radio stations from around the world. Get the latest and greatest Windows Media Player now from Product Updates.
Windows 98 Customer Service Pack available now on CD
Why does the Windows Update site appear in a different language?
Find out how to use Internet Explorer's Accept Language feature to view Windows Update in your preferred language.
The Windows 98
Internet

While it will help you keep your OS up-to-date most of the time, Windows Update can't upgrade your system fully to SE. You'll need to click on the link to order the CD for a nominal fee.

fact remains—home users will not be happy with this renamed NT 5.0. It's not designed to be compatible with the majority of games and other consumer applications that are likely to end up in a home PC. As great as 2000 is for what it's intended (so far most independent labs give it rave reviews), it is not a successor to Win98.

MAKING YOUR WINDOWS SOAR

The best upgrade you can perform on your PC right now is to make sure you are running the latest SE version of Win98. Finding out if this is the case is simple. If your machine is more than six months old and you haven't up-graded the OS, you already have your answer. If your machine is kind of new, but you're not sure how long it's been sitting on a store shelf, you'll have to check.

Go into START/SETTINGS/CONTROL PANEL and click on SYSTEM. The dialog box that comes up will tell you a build version of Windows. Something like "4.10.1998" won't cut it. You need to read "SE."

If you are one of the maybe 95 percent of our readers who does need to upgrade, don't worry. It's not costly, and the avenues it opens are well worth it.

Are you familiar with the Windows Update feature of 98? This link, which is found in your Start menu, launches Internet Explorer and opens a site that can automatically check for updates to your OS. Now, while this is normally a powerful way to keep current, the total improvements in the newer SE are just too large to download. This is why at the Update site there is a simple link that will let you order an upgrade CD for a nominal $20, plus shipping. If you plan to add new peripherals and get the best performance possible from anything considered "high speed," this may be the best $20 or so you spend on your machine.

Despite the "4 to 6 weeks" disclaimer, your CD should come within a week to 10 days. Pop it into your drive as soon as you can for increased system performance. In addition to upgrading the SE features, the disc will also take care of some of the incremental security and stability issues that you might have missed if you haven't been clicking on Windows Update often enough.

HIGH SPEED COMING YOUR WAY

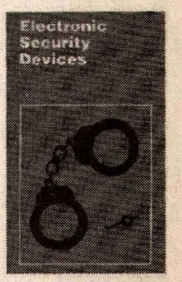
The majority of improvements made to the SE are not noticeable even to a trained eye. For the most part, things just run more smoothly; promises that were made for Win98 are better fulfilled. We like the subtle changes to dialog boxes and removal of little quirks that we'd catch from time to time. One system we installed it on stopped about five bad "habits" it had developed; including the leaving of a blank, gray rectangle on the Task Bar

(Continued on page PS-8)

ELECTRONIC GAMES

BP69—A number of interesting electronic game projects using IC's are presented. Includes 19 different projects ranging from a simple coin flipper, to a competitive reaction game, to electronic roulette, a combination lock game, a game timer and more. To order BP69 send **$4.99 clearance (includes s&h)** in the US and Canada to **Electronic Technology Today Inc., P.O. Box 240, Massapequa Park, NY 11762-0240.** US funds only. Use US bank check or International Money Order. Allow 6-8 weeks for delivery. MA07

ELECTRONIC SECURITY DEVICES



A great book for project builders. It is quite common to associate the term "Security Devices" with burglar alarms of various types. However in fact it can refer to any piece of equipment that helps to protect people or property. The text is divided into three basic sections: Chapter 1 covers switch-activated burglar alarms and includes exit and entry delays. Chapter 2 discusses other types of burglar alarms and includes Infra-Red, Ultrasonic and Doppler-Shift Systems. Chapter 3 covers other types of security devices such as Smoke and Gas Detectors; Water, Temperature and Baby Alarms; Doorphones, etc. Most circuits are simple, and stripboard layouts are provided.

To order Book BP56 and send $5.99 includes shipping and handling in the U.S. and Canada only to **Electronics Technology Today Inc.,** P.O. Box 240, Massapequa Park, NY 11762-0240. Payment in U.S. funds by U.S. Bank check or International Money Order. Please allow 6-8 weeks for delivery. ET09

THE COLLECTED WORKS OF MOHAMMED ULLYSES FIPS

#166—By Hugo Gernsback. Here is a collection of 21 April Fools Articles, reprinted from the pages of the magazines they appeared in, as a 74-page, 8½ × 11-inch book. The stories were written between 1933 and 1964. Some of the devices actually exist today. Others are just around the corner. All are fun and almost possible. Stories include the Cordless Radio Iron, The Visi-Talkie, Electronic Razor, 30-Day LP Record, Teleyeglasses and even Electronic Brain Servicing. Get your copy today. Ask for book **#166** and include **$9.99 (includes shipping and handling)** in the US (First Class), Canada and Overseas (surface mail), and order from **CLAGGK Inc., P.O. Box 4099, Farmingdale, NY 11735-0793.** Payment in US funds by US bank check or International Money Order. Allow 6-8 weeks for delivery. MA05

KONSTANTINOS KARAGIANNIS

NET WATCH

Finding MP3s

Last month we talked about how far MP3 compressed audio has come and let you in on some ways to greatly improve your enjoyment of the format. Now that you know how to make your own high-quality files and play them back with the best possible results, let's focus on some ways to acquire MP3 files from the Internet.

BUT FIRST...

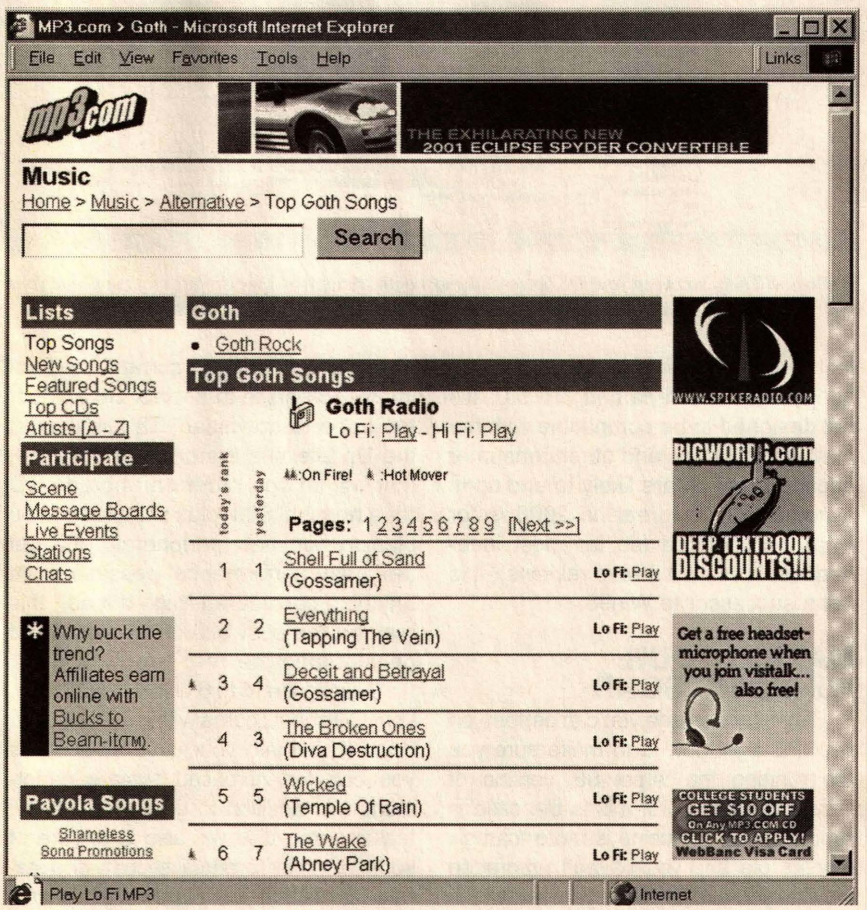
Some of you might find the temptation to be a true "hacker spirit" irresistible when dealing with MP3s. It's no big secret that the small file sizes of MP3 make it possible to encode copyrighted music and then e-mail it to friends, or to post it for all to enjoy on Usenet newsgroups. Just as you can find "Warez" pirated versions of popular games, scans of the latest racy celebrity pictorial, or a slew of other copyrighted material posted illegally in newsgroups—thousands of MP3s of commercially released songs abound there. In fact, the MP3 binaries groups probably have more postings in them than all other binaries groups combined!

Keep in mind that posting or downloading any of the aforementioned materials is a violation of copyright laws. Just like you're not supposed to make bootleg tapes of recordings and sell them or buy such knockoff copies, trading MP3s to which you don't own the copyright is illegal. While you may never have a guerilla army barge in and seize your computer because of your doing so, pirating MP3s does make you a form of criminal.

Please try to do the right thing—there are ways to enjoy MP3 legally. Here are a few:

THE NAME SAYS IT ALL

If you're searching for a business or category of interest online, you'll often do well to just type in the simplest version of your query with a ".com" after it.

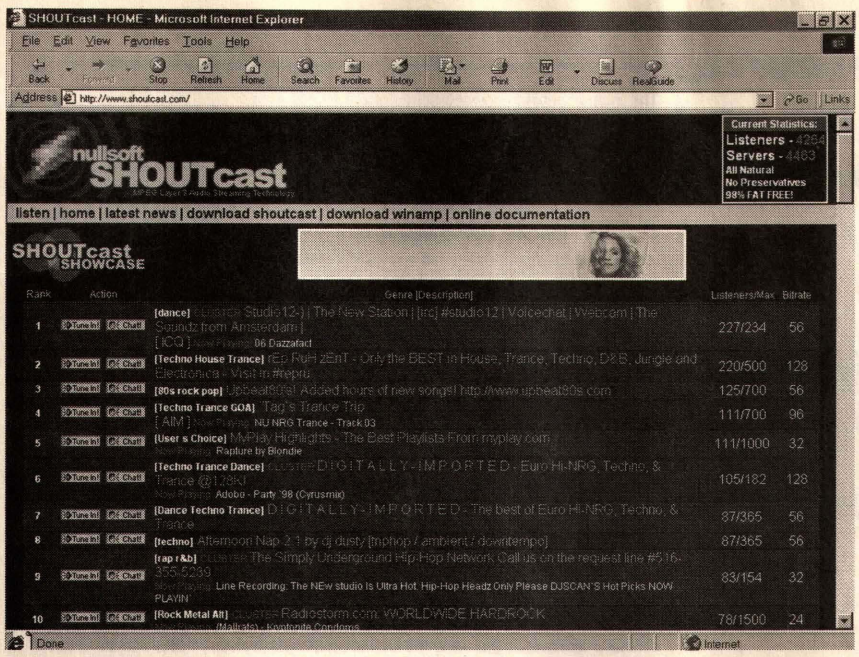


With its no-brainer domain name, MP3.com might just be the first place many look for downloadable music. What these seekers will find is an enormous selection of free, legal music from up-and-coming artists, as well as from a few established, generous names.

For things like furniture or chains like Macy's, this works like a charm, and it holds true for MP3. Pioneering the way that new and established artists gain exposure, *MP3.com* has developed an online listening board and more.

First, there are the featured selections that appear from time to time. Don't be surprised if the next time one of your favorite bands has a new album coming out you find a track or two from it posted here. This type of distribution gets hype going and gives us all a reason to fire up our MP3 players more often. Downloading one of these preview tracks lets you enjoy free, CD-quality music that you like, without guilt. It's similar to taping a tune from a radio show, but in higher quality.

The most common types of legal MP3s, though, are the ones being distributed by up-and-coming bands. These can range in quality from "tomorrow's stars" to "tunes you wish you didn't waste three minutes of your life on," but the excitement of discovery makes up for the latter grouping more often than you'd think. We've



SHOUTcast servers provide streaming MP3s of your favorite types of music from well-known artists. Think of them as up-to-CD-quality radio stations. All you need to listen is—Winamp.

found quite a few great new Gothic/ Industrial bands this way, but results in your genre of choice may vary. In any event, it is this type of new form of distribution that makes *MP3.com* sparkle.

Browsing through genres and subgenres of music, you'll be presented with lists of the most played or downloaded songs. It's a safe bet that if people are listening to a few choice groups repeatedly, something might be there worth discovering.

Each artist listing lets you read a brief biography, link to the performer's official site, and, of course, download music. Should you want to sample before filling your hard drive, check out the radio feature that lets you listen in Hi-Fi (broadband connection required) or Lo-Fi to each tune. While the full songs can be heard in this fashion, you're better off listening to short selections and then downloading for repeated playback whenever you want.

As a service to those of you who use MP3 primarily for storing your CDs on a PC, the site has even developed *My.MP3.com*. A list of CDs that you own is "beamed" to a server; you can then stream the MP3 versions of those albums over your Internet connection. We think this is a neat idea that could save you gigabytes of storage; however, it might cause bandwidth problems depending on how you access the Net. For dial-up modem users, there's an approximately FM-quality Lo-Fi version that can cut down on congestion.

SHOUT IT OUT TO THE WORLD

Speaking of streaming MP3s, here is another way to tune in your favorites without paying for them. Unlike *My.MP3.com*, where you have to physically own each song you listen to, SHOUTcast lets you stream content in a variety of genres even if you've never bought a single disc from an artist in the respective categories. While you can't store this music on your computer, SHOUTcast content can be as high as 128 Kbps in quality and thereby provides a real-time listening experience on a par with standard radio.

It's actually better than radio, as most SHOUTcast servers or "stations" don't have commercials and play really targeted music.

How do you tune in to the "insert-

(Continued on page PS-8)

HOT SITES

MP3.com
www.mp3.com

SHOUTcast
www.shoutcast.com

Winamp by Nullsoft
www.winamp.com

TIPS FOR MAIL ORDER PURCHASE

It is impossible for us to verify the claims of advertisers, including but not limited to product availability, credibility, reliability and existence of warranties. The following information is provided as a service for your protection. It is not intended to constitute legal advice and readers are advised to obtain independent advice on how to best protect their own interests based upon their individual circumstances and jurisdictions.

1. Confirm price and merchandise information with the seller, including brand, model, color or finish, accessories and rebates included in the price.

2. Understand the seller's return and/or refund policy, including the allowable return period, who pays the postage for returned merchandise and whether there is any "restocking" or "return" charge.

3. Understand the product's warranty. Is there a manufacturer's warranty, and if so, is it for a U.S. or foreign manufacturer? Note that many manufacturers assert that, even if the product comes with a U.S. manufacturer's warranty, if you purchase from an unauthorized dealer, you are not covered by the manufacturer's warranty. If in doubt, contact the manufacturer directly. In addition to, or instead of the manufacturer's warranty, the seller may offer its own warranty. In either case, what is covered by warranty, how long is the warranty period, where will the product be serviced, is there a charge for service, what do you have to do to obtain service and will the product be repaired or replaced? You may want to receive a copy of the written warranty before placing your order.

4. Keep a copy of all transactions, including but not limited to cancelled check, receipt and correspondence. For phone orders, make a note of the order including merchandise ordered, price, order date, expected delivery date and salesperson's name.

5. If the merchandise is not shipped within the promised time, or if no time was promised, within 30 days of receipt of the order, you generally have the right to cancel the order and get a refund.

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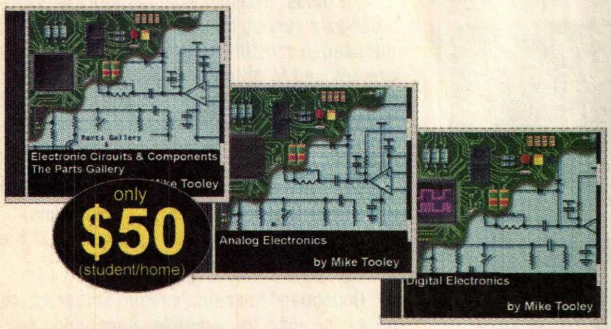

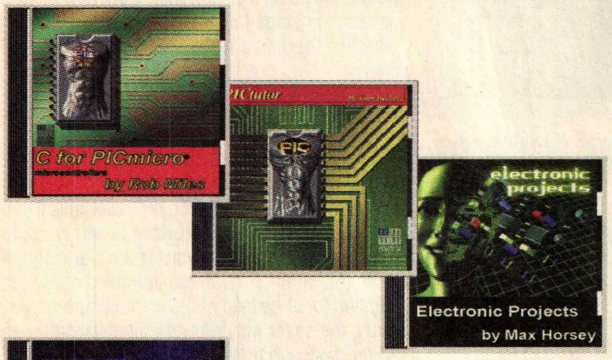

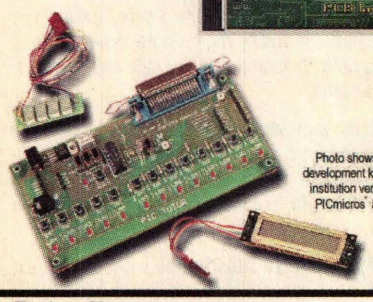

Photo shows PICmicro® development kit supplied with institution versions of C for PICmicros® and PICtutor

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Electronic Circuits and Components provides an introduction to the principles and application of the most common types of electronic components and how they are used to form complete circuits. Sections on the disc include: fundamental electronic theory, active components, passive components, analogue circuits and digital circuits.

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JOHN IOVINE

Kirlian Photography

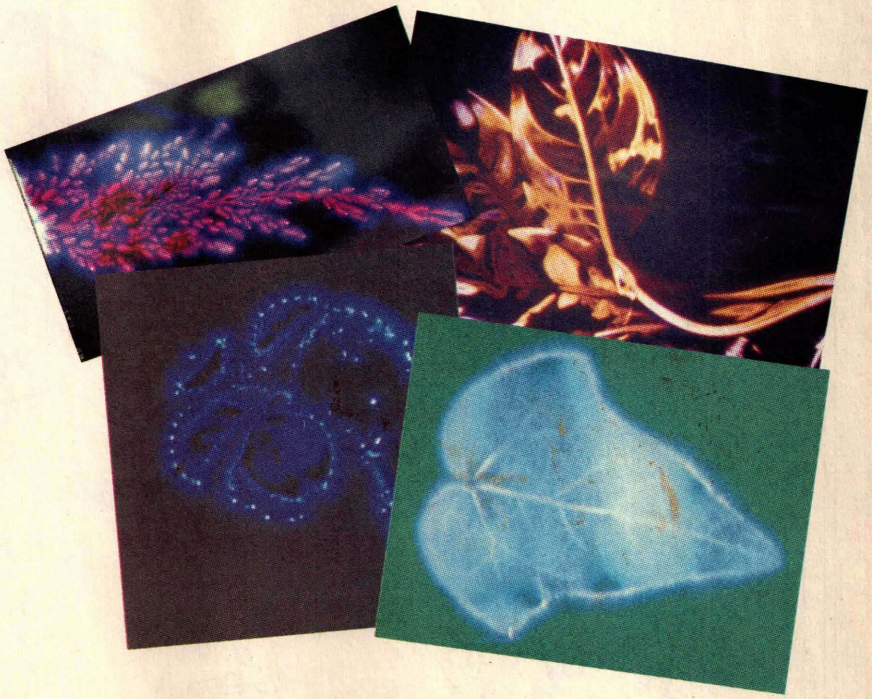
Kirlian photography is a method of creating contact-print photographs with high voltage. The process is simple: Sheet film is placed on top of a metal plate, and the object to be photographed is placed on top of the film. High voltage is applied to the plate momentarily to make an exposure. The corona discharge between the object and the high-voltage plate is recorded onto the film. When the film is developed, you have a Kirlian photograph of the object. The general arrangement of the system is shown in Fig. 1.

Since this is a contact print process, the Kirlian process doesn't require the use of a camera or lens. However, when a transparent electrode is substituted for the discharge plate, it is possible to use either a standard camera with a flash setting or a video camera. I'll take a closer look at that next month; now let's get a basic setup working.

I've experimented with Kirlian photography over the years. When the subject was first introduced to America in the early 1970s with the book *Psychic Discoveries Behind the Iron Curtain* by Shelia Ostrander and Lynn Schroeder, many paranormal claims were made concerning the resulting images. For instance, it was said that the Kirlian photograph could foretell illness in plants and animals before there were signs of disease.

The most amazing claim by far (in my opinion) was known as the "phantom-leaf" experiment. A small portion of a leaf is cut off; the leaf is then photographed using Kirlian photography. In a small percentage of cases, the cut portion of the leaf appears in the photograph as a ghostly apparition. The appearance of the cut portion of the leaf—as claimed by the Soviet researchers—is proof of an "ethereal bio-plasma body."

Although a few Kirlian researchers have claimed to duplicate the phantom-leaf experiment in their own labs, the most successful results in the form of actual phantom-leaf photographs are reported from Soviet researchers. For whatever reason, my attempts to duplicate that experiment have not met with resounding success; the exact experimental parameters (voltage, frequency, etc.) either are not available or didn't work for me.



These examples of Kirlian photography demonstrate the artistic beauty that can be achieved from a photography method originally designed for scientific study.

Much of the phenomena considered paranormal by these researchers can be explained with known physical laws. Changes in a subject's skin resistance due to factors like stress, illness, fatigue, or alcohol consumption can yield the same results without the necessity of invoking paranormal (bio-plasma) factors. Other factors influencing the Kirlian picture include the object's pressure against the film, humidity, air pressure, voltage, frequency, and exposure time.

Since I have never observed any of the paranormal claims frequently associated with Kirlian photography, why do I continue to experiment in the field? First, I like Kirlian photographs. I think that Kirlian photographs are unique and oftentimes beautiful. Second, I like exploring. I have looked for the phantom-leaf effect over the years; although as I've said, I have never observed the phenomenon. If the phantom leaf does exist, it might be the starting point of a new paradigm. My excursions into Kirlian photography are sporadic. Typically, I add a new twist into the old photography apparatus and check for new results. Finally, Kirlian photography has the potential for becoming a diagnostic tool (both biological and industrial).

A Kirlian Device Of Your Own

The Kirlian device you're going to

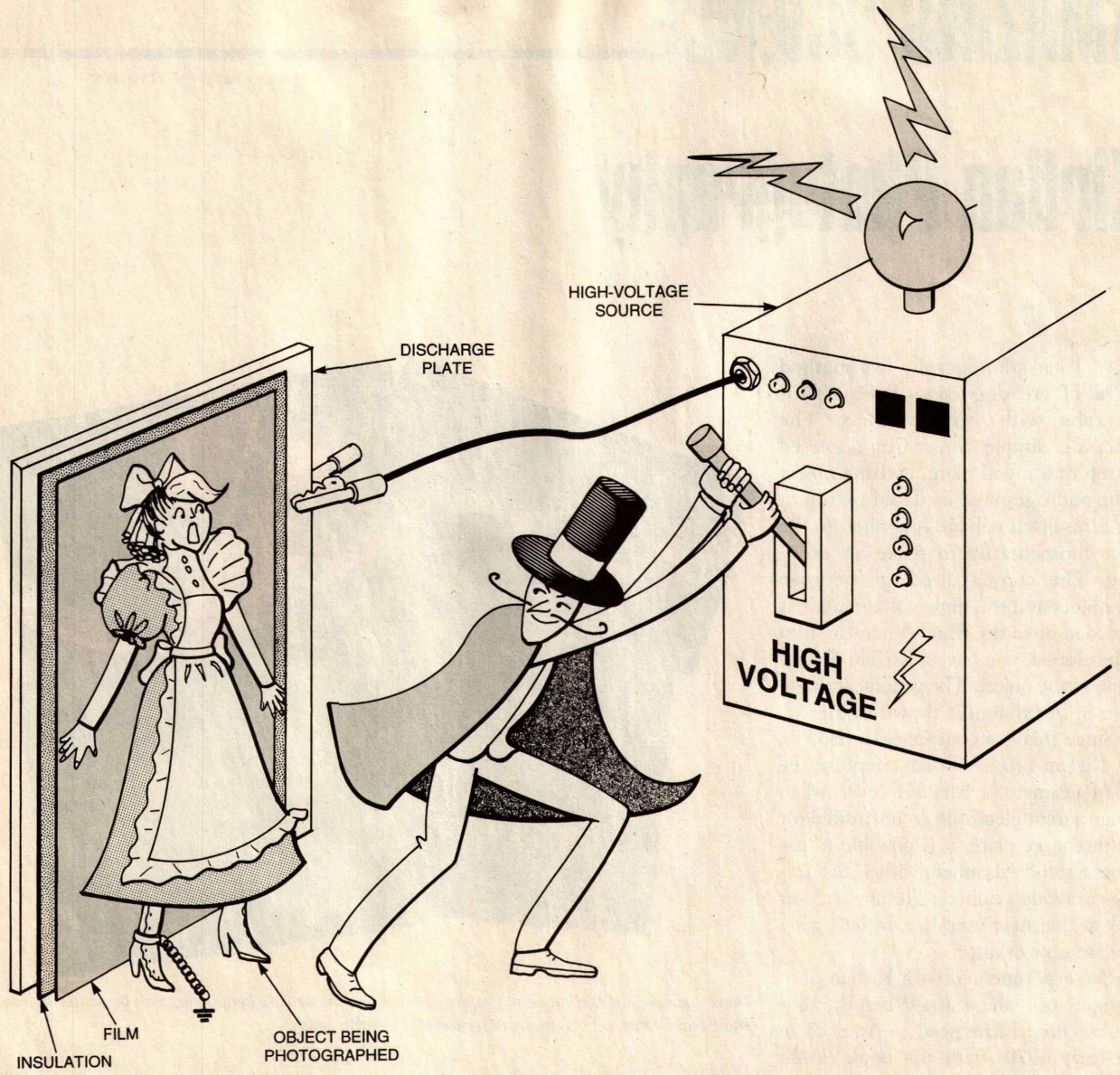


Fig. 1. In Kirlian photography, a high-voltage pulse is passed through a sheet of film to electrify the subject being photographed.

build uses a high-voltage transformer. It is battery powered for portability, but don't let that lull you into a false sense of safety. I would be irresponsible if I didn't keep your health and well-being in mind, so I can't stress the following statement enough:

Warning: The Kirlian device generates pulses of high voltage that can provide a nasty shock.

The schematic diagram for the high-voltage circuit is shown in Fig. 2. As you can see, it is a simple manual device that uses very few components; you would be hard-pressed to find a simpler device that works as well.

Batteries B1 and B2 are 67½-volt instrument batteries that are wired in series to produce 135 volts. If those batteries are not available, you may want to try wiring ten or more 9-volt batteries in series. The discharge will not be as intense, but it will work. Another option would be to take the output from a 24-volt step-down transformer and connect it to a voltage step-up circuit that would quadruple the voltage. In that case, the resulting voltage will be about 100 volts. While you lose the portability feature of the device, you won't have to worry about finding exotic batteries.

Capacitors C1—C4 are wired in parallel and connected to the primary of T1, a high-voltage autotransformer—"auto" as in self-inductive, not auto, like automobile. Since it's a high-voltage transformer, T1 has only three wires coming out of it: two enameled wires and one green insulated wire from its center. The green insulated wire is the high-voltage wire that connects to the discharge plate.

Switch S1 is a single-pole, double-throw, momentary-contact switch with a spring return, so it doesn't lock or stay in the opposite position. The switch is wired so that its normally-closed contacts connect the primary of T1 to the negative terminal of B2 and the capacitors. The switch is important and must be wired correctly to obtain the best performance from the batteries. When

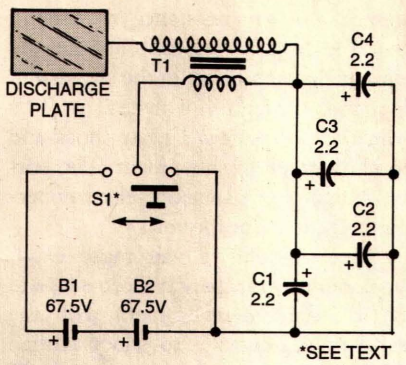


Fig. 2. The circuit for a Kirlian-photography device is simple and straightforward. Pressing S1 charges the capacitor bank; releasing the switch discharges the capacitors through a high-voltage transformer. The basic action of the circuit is similar in concept to automobile ignition systems.

the switch is "at rest," B1 and B2 are disconnected from the circuit; C1—C4 are also held discharged through T1's primary winding. That prevents a potential shock hazard from being stored in the capacitors and unleashed on an unsuspecting experimenter.

When S1 is pressed, the capacitors are disconnected from T1 and reconnected to the batteries. Current flows into the capacitors, charging them. Releasing S1 disconnects the batteries and puts the now-charged capacitors back across T1's primary. The voltage spike from the capacitor discharge creates a high-voltage spike in T1's secondary.

Building the circuit can be as plain or as fancy as you want. For my unit, I used the time-honored "nail-'em-down-and-wire-'em" method that recalls the days of vacuum tubes, open-frame chassis, and the accompanying "rat's-nest" of wires. Simply mount all of the parts on a piece of wood; mine measured about 8 by 10 inches. You can use glue or epoxy to mount the components. An alternative is clamps and screws, which makes it easier to replace any failed parts. Keep the lower-voltage wiring neat, tidy, and away from any high-voltage conductors.

When it comes to mounting S1, get a bit creative. I used a metal 9-volt battery clip as a bracket. Bend the clip into a "U" shape and drill appropriate holes in the "ears" for screws; you'll also need a large hole in the top for S1. The switch is held in place with the nut that should come with it. Mount the assembly to the base with some wood screws through the ears of the bracket. The general arrangement I used to mount S1 is shown in Fig. 3.

Exposure Plate

The discharge plate is made from a 4- by 6-inch piece of single-sided PC board. The high-voltage output wire from T1 is soldered to a corner of the board, and the board is glued to the wood board with the copper side up. After the glue dries, cover the plate with a thin plastic sheet about 0.005 inch thick (available from many art and drafting-supply stores). The actual thickness of the plastic sheet isn't critical as long as it prevents the object from making direct contact with the discharge plate. The plastic sheet can be transparent or opaque. Don't worry about passing light, only about electric charge.

The plastic should extend at least 1 inch past the discharge plate on all sides. Don't glue or tape the sheet to the plate until after the initial tests are done.

First Tests

To test the circuit, attach a wire to the positive side of the capacitor bank. Hold the other end of the wire about ¼ inch away from the discharge plate. Every time you flick S1, you should see a spark jump from the wire to the discharge plate.

When the circuit checks out properly, glue or tape the plastic insulating sheet to the top of the discharge plate. Make sure that the entire plate is covered.

Coat any exposed wires with a plastic spray to provide insulation. One type that is easy to find is called "No-Arc Spray;" it's available at your local RadioShack store.

Black-and-White Film

Kodalith 2556 type 3 ortho film is a high-contrast, black-and-white, graphics-arts film that's available in 4- by 5-inch sheets in any most well-stock camera stores. Ortho film is normally used to create photographic images for the printing industry; it can create very sharp edges. The developed film image has two states: opaque or clear. With a very low ASA speed rating (something around 1!), exposure times can be measured in seconds or minutes instead of the fraction of a second that you normally see in regular photography. This film is perfect for beginners because you can use a red safelight and not have to work in complete darkness. If a safelight isn't readily available, you can try using a red LED or a neon lamp, or you can wrap red acetate plastic over a dim 4-watt bulb.

I advise all beginners to start with black and white ortho film. It is less costly and easier to work with than color sheet film. You also have the opportunity to develop the film to get immediate feedback. With color film, you have to wait to get the film developed to see the results.

Developing black-and-white ortho film is easy. The chemistry works quickly and is simple and forgiving. You only need two chemicals: Developer and fixer. A stop bath is usually employed in between those two steps, but isn't necessary.

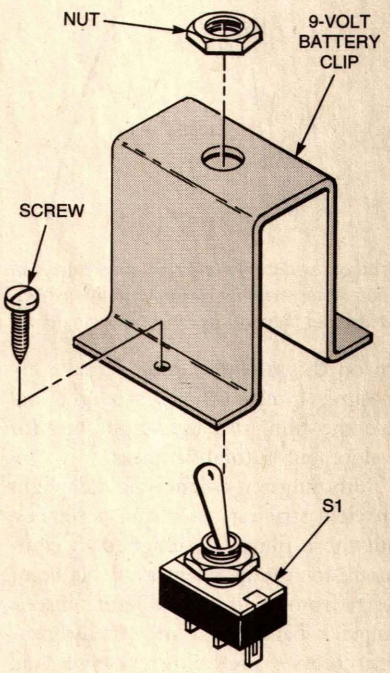


Fig. 3. To mount S1 to the Kirlian device's base, bend a 9-volt battery clip into the "U" shape shown: a cheap way to make a mounting bracket!

On the down side, a black and white image (film or print) is not as spectacular as color. However, the experience that one gains by observing all of the steps under a safelight is invaluable; complete darkness is needed when working with color film. Using a high-voltage power supply in the dark can be a daunting task, so it's best to familiarize yourself with the process in the least costly manner.

Color Film—Daylight or Tungsten-Balanced

Color film requires exposures to be made in total darkness. For obvious reasons, working in total darkness can be a problem. Sometimes I sandwich the color film between two black opaque sheets of paper in total darkness, then

For all of the dangers and risks associated with high voltage, a properly designed and functioning Kirlian system will not cause harm to anyone. If you photograph a living object such as a person, the most that they will feel is a slight tingle; the resulting image can be truly striking!

turn on the safelight. After I make my exposure, I turn off the safelight and place the film in a light-tight box for development in total darkness.

Both tungsten-balanced and daylight film yield striking color transparencies. Both those films are designed to compensate for the different available color spectra from the indicated light sources. Tungsten-balanced film usually produces colors in the yellows, oranges, and reds. Daylight film usually produces colors in the blues and greens.

As you start to experiment with your Kirlian device, you'll probably want to try photographing the "aura" of people like yourself or your friends. Keep in mind the following points:

The voltage-pulse source presented here is somewhat weak for safety purposes. If you try to take a photo of someone's hand, the results will be dark and disappointing. The problem is that a human hand has too much surface area for the amount of charge that's available from our setup. The discharge during the pulse will be spread so thin that there won't be sufficient electrical corona to make a decent exposure. While you can take such a picture successfully with a higher-capacity power source, the resulting dangers multiply accordingly should something go wrong. Our unit does have enough power to photograph a finger or two.

You should **never** try to take a Kirlian photograph of yourself! Take another look at the schematic diagram. Let's assume that you want to take a Kirlian photo of your left thumb. That means that you'll have to operate S1 with your right hand. Since you (the subject) need to be grounded, your grounded right hand will be in contact with the metal of the S1 switch. If you present a lower resistance to ground than T1, there is the possibility that the capacitor pulse will arc in the switch and discharge through you instead of T1's primary; the result is a nasty shock and no photograph to show for it. The bottom line is to get someone else to operate the equipment for you.

Next month, we will make exposures, build a transparent electrode, and use a 35-millimeter camera with the transparent electrode to shoot Kirlian photographs. P

PARTS LIST FOR THE KIRLIAN-PHOTOGRAPHY DEVICE

B1, B2—67½-volt photo batteries
C1–C4—2.2-µF, 250-WVDC capacitors
S1—Single-pole, double-throw, normally-open, momentary-contact switch, spring-loaded
T1—High-voltage transformer
4- by 6-inch single-sided, copper-clad PC board, plastic sheet, 9-volt battery clip, wood baseplate, wire, hardware, etc.
Note: The following items are available from Images Company, PO Box 140742, Staten Island, NY 10314; 718-698-8305; *www.imagesco.com:* C1–C4, $2.50 each; S1, $3.95; T1, $29.95; PC board, $5; Plastic sheet, $1. NY residents must add appropriate sales tax.

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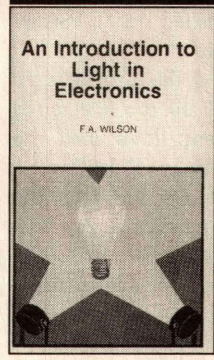
An Introduction to Light in Electronics



Taken for granted by us all perhaps, yet this book could not be read without it, light plays such an impressive role in daily life that we may be tempted to consider just how much we understand it. This book makes a good start into this fascinating and enlightening subject. It has been written with the general electronics enthusiast in mind.

To order Book #BP359 send $6.99 plus $3.00 for shipping in the U.S. and Canada only to Electronics Technology Today Inc., P.O. Box 240, Massapequa Park, NY 11762-0240. Payment in U.S. funds by U.S. bank check or International Money Order. Please allow 6-8 weeks for delivery.

ET08

Practical PIC Microcontroller Projects

This book covers a wide range of PIC based projects, including such things as digitally controlled power supplies, transistor checkers, a simple capacitance meter, reaction tester, digital dice, digital locks, a stereo audio level meter, and MIDI pedals for use with electronic music systems. In most cases the circuits are very simple and they are easily constructed. Full component lists and software listings are provided. For more information about PICs we suggest you take a look at BP394 -- An Introduction to PIC Microcontrollers.

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A Hands-on Electronics® REPORT

Pioneer PDV-LV10 Portable DVD Player

Whether laid up with the flu, traveling on business, or making a road trip with a cranky child, this portable DVD player makes the time pass much more pleasantly.

It's been close to two months since I received the Pioneer *PDV-LV10* for testing. (That's twice the time stipulated in the loan agreement, but between the holidays, a bout with the flu, and the annual trek to the Consumer Electronics Show in Las Vegas, I've fallen behind schedule.)

I must admit that, when the PDV-LV10 arrived, I was skeptical. Sure, it's cool, but honestly, when would I use a portable DVD player? I could bring it on plane trips if I was a frequent traveler. (I'm not.) I could take it along and hook it up to the TV and sound system at my vacation house, if I had one. (I don't.) It could keep the kids occupied in the back seat, if my family took frequent long trips by car. (We don't.)

Spending two months with the PDV-LV10 was a real eye-opener. Let's start with the holidays. This year's family trip from Long Island to Manhattan to visit Santa at Macy's also included, for the first time, the Christmas Spectacular at Radio City followed by dinner in a theme restaurant. The train ride home, with an exhausted four-year-old, could have been torture. Instead, we popped *Pokemon: The Mystery of Mount Moon* into the portable DVD player and enjoyed a peaceful end to a busy day. The bumper-to-bumper drive to Grandpa's for Christmas dinner, with a sleep-deprived and overstimulated child in the back seat, was also rendered painless by the PDV-LV10 and *Elmopalooza!*.

Then the flu struck, leaving me bedridden for almost a week. Because of my job, electronics gear fills almost every inch of the house. Only the bedroom is electronics free—not even a clock radio. I was faced with the prospect of staring at the ceiling or reading

the trashy novels that were all my flu-weakened brain could handle. The PDV-LV10 saved my sanity!

By the time CES rolled around, I wouldn't have considered flying to Las Vegas without bringing DVDs along for my own choice of in-flight movies. Since the PDV-LV10 doubles as a CD player, I could enjoy music in the hotel room as well.

Design and Features. The PDV-LV10 is a compact, two-piece unit, consisting of the player itself and the battery case/docking station for portable use. The main unit, which can serve as a full-function home DVD deck, complete with remote control, measures 7½ × 5½ × 1 inches. Attaching it to the battery case adds an inch in height and a half-inch in width and brings its traveling weight to about three pounds. You get 3fi hours of viewing time from a fully-charged battery. An optional extra battery pack (PDV-BT10) costs $99.

The player's base houses the control buttons and the disc compartment, which opens via a slide switch on the left side of the unit. The main controls are laid out in a circular arrangement, with the playback and menu-navigation buttons circling a round pad that provides left, right, up, and down cursor control. Below those controls are the return button, which returns to the main menu from a submenu or exits the setup menu, and the stop button.

In addition to the control buttons, there's a small display that indicates a low-battery, a chapter or track number, and elapsed time. The front panel is home to the power switch, IR sensor, and a headphone jack. On the right side of the player are jacks for A/V in/out and S-Video out, an AV in/out switch, and the volume control.

The outside of the player is attractively finished in champagne-colored brushed aluminum, and its interior is matte brown. When the top of the unit is flipped open, a seven-inch, 16:9 active-matrix LCD screen is revealed, plus two tiny built-in speakers, and color and brightness controls.

The seven-inch widescreen LCD displays a surprisingly clear and realistic image. Discs that contained high contrast—including kid's vids such as *Pokemon* and *Elmopalooza!*—were particularly well-suited for playback on the PDV-LC10, even when viewed in the high ambient light of a Long Island Rail Road car.

The tiny speakers, however, were disappointing. The sound quality was thin and tinny. Even with the volume cranked up, they weren't powerful enough to disturb other train passengers. Using headphones improved the sound dramatically; but unless the PDV-LC10 is connected to a 5.1-channel surround sound system, it can't take advantage of the superb sound afforded by the DVD format.

Image Quality. When I was home with the flu, I watched an eclectic variety of discs. Watching on a small screen did not detract from the intensity of *The Blair Witch Project*. In fact, it gave the viewing

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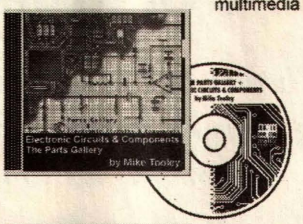

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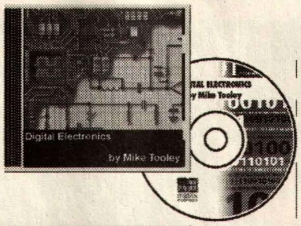

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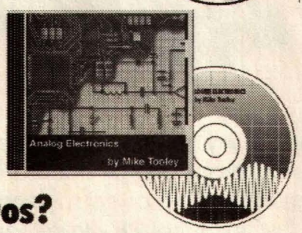

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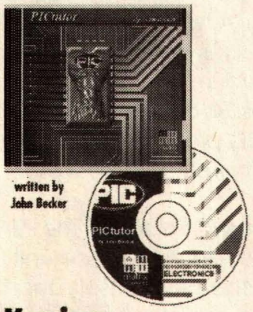
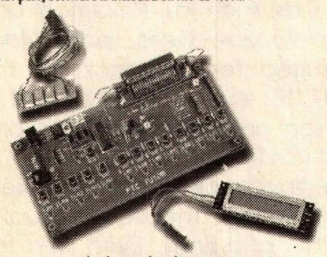


The complementary development kit includes a reprogrammable PIC16C84, which you can program via your printer port. The institution version (designed for use in schools, colleges and industry) includes a quad 7-segment LED display and alphanumeric LCD display. The development kit provides an excellent platform for both learning PIC programming and for further project/development work. Assembler and send (via printer port) software is included on the CD ROM.



development board (institution version)

Prices and Versions

Institution versions are suitable for use in schools, colleges and industry. Student versions are for student/home use.

	student version	institution version
Electronic Circuits & Components	$56	$159
Digital Electronics	$75	$189
Analog Electronics	$75	$189
PICtutor (CD and development board)	$179	$350

Shipping costs to Canada an additional $5. Overseas orders please contact CLAGGK Inc. for shipping costs.

see http://www.MatrixMultimedia.co.uk for full specs and demos

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CL02

Claggk Inc., PO Box 4099, Farmingdale, NY 11735-0792
Tel: 516-293-3751 email claggk@poptronix.com

experience an odd sense of intimacy and of peering secretively into the film's quirky, "jumpy" video. Even the poor audio quality seemed to match the home-brewed quality of the film. Low-contrast scenes were difficult to see—but not much more so than when viewed on a full-size television.

On the other hand, *Armageddon* demands a big screen and full surround effects to bring its action scenes to life. Similarly, much of the beauty of the sets and costumes of *Shakespeare in Love* were lost on the small screen. That film, however, and other relationship-driven stories (*As Good as it Gets, Good Will Hunting*) fared well on the PDV-LC10, whether viewed from a sickbed or a seat on an airplane.

Connect the unit to a home-entertainment system that's equipped with the requisite decoders and speakers, and you can enjoy DVD video and audio in all their splendor. The PDV-LC10's front-panel headphone jack also serves as a digital optical output, ensuring Dolby Digital and DTS compatibility. The tiny remote control provides armchair convenience while the viewer studies the on-screen menus or selects playback options.

At $1545, the PDV-LC10 is priced much higher than most home decks, but its versatility makes the price tag easier to swallow. If your lifestyle is a bit nomadic—traveling often for business and/or pleasure, splitting your time between home and a seasonal vacation house or an RV—the PDV-LC10 can let you enjoy DVD video wherever you roam. Even if you're more sedentary, you just might find, as I did, that there's plenty of room in your life for portable DVD.

For more information on the PDV-LC10, contact Pioneer Electronics, 2265 East 220th St., Long Beach, CA 90801; 213-PIONEER; or circle 80 on the Free information Card. P

Don't lose sight of Glaucoma.

NATIONAL EYE HEALTH EDUCATION PROGRAM

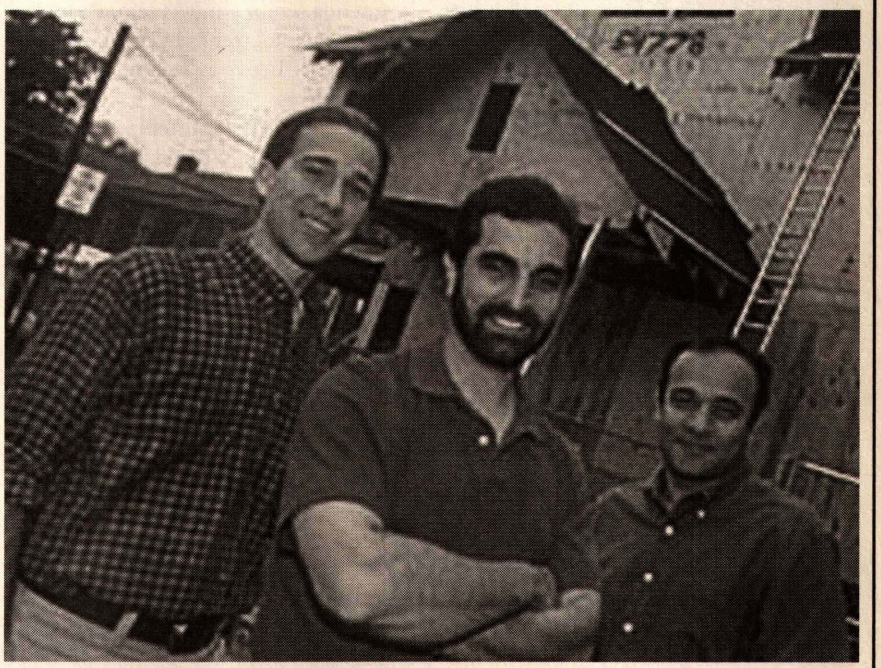
Prototype

"Home—Phone for Help!"

What if your elderly relatives live alone? Dangers lurk in the very homes that give them a sense of security. Yet they worry and you worry about them: about falling, forgetting to take their medications or taking the wrong dosage, or even leaving a burner on under an empty pot. This dilemma is all too common as people live longer and older parents and adult children live far away from one another.

What if there were a network of sensors and computers installed throughout the home? The system could warn of impending problems, set off a reminder of important routines, encourage the resident to get some exercise, and even call emergency services if it could not get anyone to respond.

Scary or exciting as this type of decision-making computer network may sound, it's probably going to be a reality early in this century. Its applications are far-reaching and seemingly limited only by human ingenuity.



The Broadband Institute Residential Laboratory under construction near the Georgia Tech campus will be the host for the "Aware Home" project. Pictured here are Dr. Irfan Essa (right), Dr. Gregory Abowd (center) and student researcher Corey Kidd (left) who are among those investigating ubiquitous computing.

Ubiquitous Computing

As society breaks away from the desktop computer, computers with human-like perception will emerge, ushering in the era of ubiquitous computing. Known as ubicomp, the term refers to an environment where computers are constantly present, seamlessly integrated, and part of everyday life.

"The traditional desktop computer helps to an extent with daily life," says Dr. Irfan Essa, assistant professor in the Georgia Institute of Technology College of Computing. "But we believe the computer should not be limited to the desktop. It should be a part of the room."

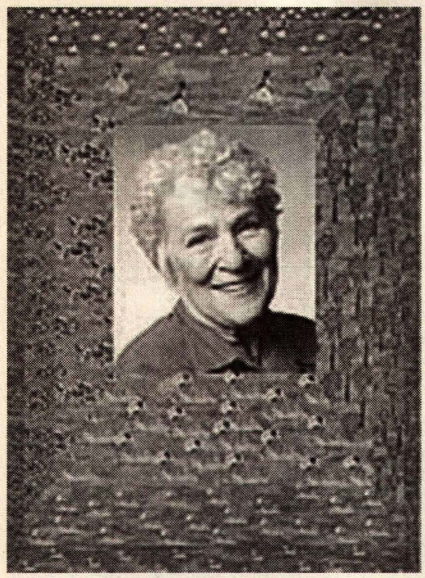
If computers are ubiquitous, then they should also be smarter, according to researchers in Georgia Tech's Future Computing Environments (FCE) group. "The next generation of technology will have computers understanding what people are doing and what they want," says Associate Professor and FCE co-founder Dr. Chris Atkeson. "The basic expectation is that humans have a clue. For now, computers don't have a clue."

Since 1995, the FCE group has been investigating the ubicomp and aware computing concepts in "living laboratories." Their latest effort is an experimental house, the Broadband Institute Residential Laboratory, also known as the "Aware Home" project by the researchers involved.

The Residential Laboratory is scheduled to start functioning in June. When it opens near the Georgia Tech campus, the house will be capable of knowing information about itself and the whereabouts and activities of its inhabitants.

The laboratory, under the guidance of The Broadband Institute, was funded by a $700,000 grant from the Georgia Research Alliance, a consortium of more than 20 information technology companies. The 5040-square-foot house will host a broad range of communications-related research, according to Broadband Institute Director Dr. Nikil Jayant.

The three-story Residential Laboratory includes two independent, two-bedroom living areas; and a basement with a high-performance computing and a shared home entertainment section. One living area will serve mainly for



Digital Family Portraits created by Dr. Beth Mynatt, an assistant professor of computing, help family members follow senior relatives. The picture frame, a flat-panel display, uses icons to give a sense of how the subject is doing.

experimental purposes; the other will initially host students and an elderly person or family later on.

Your House is Your Best Friend

"Aware Home" researchers want to build an environment that can sense the inhabitants by seeing, hearing, and measuring contact through a variety of sensing technologies: video, audio, motion, and load. Atkeson says, "The computer will be aware of who people are and what they are doing, rather than needing a human being in charge of the remote control, for example. This is the next generation of computing."

Members of the FCE group are simultaneously focusing on human- and technology-centered studies in the Aware Home. "The human challenge with this technology is as much a challenge, if not more than the technological challenge," says Assistant Professor and FCE co-founder Dr. Gregory Abowd. The goal is to prevent information overload, avoid invasion of the occupant's privacy, and create practical ubicomp applications for the everyday user.

The FCE group determined that the most important potential users initially are senior adults. An Aware Home initiative called "Aging in Place" is aimed at finding ubicomp technology applications that will allow senior adults to live independently in their homes as long as possible. The benefits are both social and financial. Eventually, ubicomp technology in the home might be less costly that the $2000 or more per month it can cost to live in an assisted care or nursing home facility, commented Assistant Professor Dr. Beth Mynatt.

Specifically, "Aging in Place" would program the Aware Home to sense and identify potential crises, and then automatically contact services as needed; to augment a senior adult's memory; and to track behavioral trends by creating social connections between senior adults and their relatives.

In terms of crisis intervention, basic sensing technology could help relatives determine when an incident has occurred or prevent it from occurring. For example, the Aware Home could alert the resident when the home is getting dangerously cold. It could ask, "Are you doing this on purpose?" Researchers, including Dr. Wendy Rogers in the Georgia Tech School of Psychology, are addressing how to effectively communicate with occupants.

Another goal of "Aging in Place" is memory augmentation, or cognitive support, which helps people in their day-to-day routines. For example, senior adults often deal with the difficult problem of interruption. If senior adults are preparing a meal and get interrupted by a knock at the front door, they sometimes need help remembering what they were doing when they return to the kitchen. The aware system would jog their memory by offering displays of key snapshots taken by vision sensors in the kitchen before the interruption.

The Family Portrait is Watching You

The third objective, behavioral trend tracking, is what Mynatt calls "the peace of mind quotient." She and her students created "Digital Family Portraits" for family members to follow their senior relatives' routines and activities, both daily and over time. It also provides family members with insight into their relatives' lives.

The frame of the picture, which would be a flat-panel display, is dynamic. Age-appropriate, engaging icons in the frame can give relatives a sense of how the senior adult is doing, Mynatt explains. The icons represent concepts of health, relationships, activity and events. For example, the Aware Home uses sensing technology to get a general idea of whether the senior adult interacted with anyone today,.

The three bands in the frame represent different periods of time. The center band represents today, the second band represents a summary of the past four days and the third represents the past two weeks. Icons in the band decrease in size from the center to the outer bands to represent the various time periods. The icons vary in density to represent quantity in each of the four categories. Then family members could recognize, for example, that their senior relative's activity level seems to be going down over time. That might prompt them to investigate further.

"They won't necessarily be diagnosing the problem; it's just that this sort of contact makes the situation seem less scary," Mynatt says.

Computers Everywhere

If the future is ubicomp, how long will it take to get there? Estimates vary, but FCE researchers believe houses equipped with Aware Home technology could be available within a decade. With ads now for "Smart Home" devices, consumers might wonder what more they might need in ten years. But Aware Home technology is really different.

"The critical difference is the current technology has people telling computers what to do," Atkeson says. "The next generation of technology will have computers understanding what people are doing and what they want.". PT

"Zap It to Me!"

Two leading manufacturers, Evercel, Inc. and Zapworld.com, have agreed to jointly produce a line of premium products using Zapworld's consumer electric vehicles (EVs), combined with Evercel's rechargeable nickel-zinc (Ni-Zn) batteries.

Under the agreement, Zapworld.com (ZAP) will install Evercel's Ni-Zn battery in a high-end version of ZAP's Lectra electric motorcycle. This motorcycle is said to have the most advanced

technologies available in electric energy storage, display, and delivery. The Lectra will be the first Evercel-powered product available to U.S. consumers.

"The ZAP Lectra is a state-of-the art, high-performance electric motorcycle and a perfect application for our premium batteries," said Robert L. Kanode, president and CEO of Evercel.

ZAP will also distribute Evercel batteries in the U.S. for a variety of other high-performance EVs including law-enforcement, folding, and low-speed EVs, such as neighborhood vehicles. Gary Starr, ZAP CEO, stated, "Evercel's new battery enables ZAP to provide a high-performance electric vehicle that greatly extends range."

The first ZAP bikes with Evercel batteries are expected to reach the market in late 2000. PT

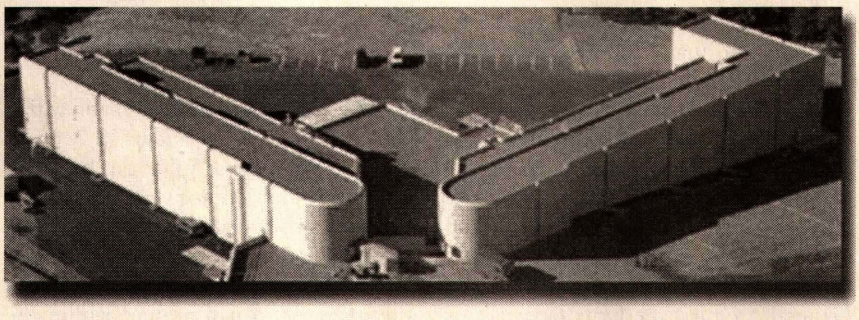
Freeze—Don t Move

The Dual-Axis Radiographic Hydrodynamic Test facility (DARHT) is a massive X-ray machine located at the Department of Energy's (DOE) Los Alamos National Laboratory. It is built to provide valuable freeze-frame photos of materials imploding at speeds more than 100,000 miles an hour.

The newest and largest experimental facility to come on line to date in the U.S. stockpile stewardship program, DARHT ensures the safety and reliability of the U.S. nuclear arsenal without nuclear testing. The process of taking these freeze-frame photos does not lead to a nuclear reaction, but only provides a nonnuclear replication of what occurs in a real nuclear weapon when the primary stage implodes. In a complete weapon, the primary stage acts as the trigger for the nuclear explosion.

"Simply put, DARHT's X-rays are as key to the U.S. nuclear stockpile stewardship program as hospital X-rays are to helping to assess the health of the human body," said Energy Secretary Bill Richardson. As the lead experimentalist for the test, Todd Kauppila of Los Alamos' Dynamic Experimentation Division felt "The test went very well....Initial indications are that we have a very high-resolution picture and an exciting new tool to investigate the dynamics of implosions."

DARHT is capable of generating a beam of power equivalent to 20,000 chest X-rays. The facility's walls, built of specially reinforced concrete, are more than five feet thick in the area facing the high-explosives test. DARHT has the ability to handle explosive loads up to the equivalent of 150 pounds of TNT.



DARHT will include two high-intensity X-ray machines orientated at right angles. Each machine has been designed to generate radiographs that will produce data of far higher resolution than previously obtainable. The dual-axis nature of DARHT will allow researches to obtain three-dimensional or time-resolved information.

Recently, DARHT's first hydrodynamic test was successfully performed. The test is called hydrodynamic because metals and other materials flow like liquids when driven by the high pressures and temperatures generated by the detonation of high explosives. The successful test marks the operational readiness of the first phase of the facility.

DARHT's team comprises about 150 Laboratory employees and subcontractors, and includes staff from Lawrence Livermore and Lawrence Berkeley National Laboratories. The budget for the recently completed first phase of DARHT is about $105.7 million. When the second phase is completed in 2002, the site will have two giant X-ray machines set at right angles, providing a more complete picture of what materials are doing as they implode. The second phase is estimated at a budget of $154 million.

According to Los Alamos Director John Browne, "DARHT gives us a tool that we need when every year we certify the safety and reliability of the nuclear stockpile to the Secretary of Energy and Secretary of Defense, who then certify to the President." PT

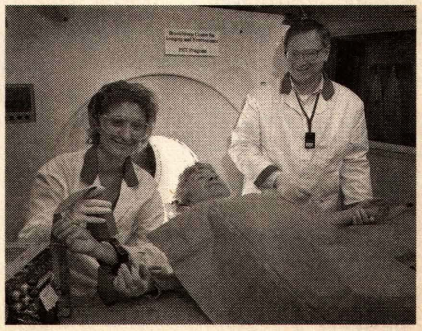
No Bleeding Needed

Brookhaven National Laboratory and CTI, Inc. have agreed to develop a non-invasive blood monitor to be used in medical imaging. Information on metabolic rate, which the new device will help measure is important for diagnosing cancer, epilepsy, and cardiac disorders.

The blood monitor is attached to a cuff that clamps on to a patient wrist, and it is used in *p*ositron *e*mission *t*omography (PET). In this imaging method, radioactive tracers are injected into the patient, flow through the blood, and concentrate in areas that have increased blood flow, or active metabolism. Built into the device, the detector actually measures the radioactivity in the artery, and this data is used to calculate glucose metabolism.

At present, metabolic rate is measured by inserting a catheter into a patient's artery. The new monitor will allow physicians to take measurements of the patient's blood without actually puncturing an artery.

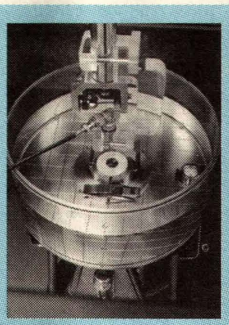
David Schlyer, the project's principal researcher at the Lab, said, "The noninvasive method would be medically safer than using a catheter, since it eliminates the risk of infection and the potential loss of blood flow to the hand. Also, it would be more comfortable for the patient."



➤ Sounding Off on Cracks

A cracked bolt may not faze a "do-it-yourselfer" doing home improvements, but it can debilitate an industrial or nuclear plant if undetected. A new inspection device developed at the Pacific Northwest National Laboratory (PNNL) detects cracks in bolts more easily and less expensively than alternatives.

Pacific Northwest's device relies on ultrasonic electronics to retrieve more accurate readings by limiting background noise. Also, the device allows fasteners to be inspected while in place, thereby reducing inspection time and allowing periodic monitoring. Inspectors have a greater opportunity to interpret the data and make repair decisions with a computer tool that gives a visual representation of the fastener and any fractures or degradation.



This inspection device developed at PNNL uses a sonar-like sensor to look through the end of fasteners to develop images of small cracks and corrosion features. In this image, the bolt's threaded end is centrally located with the sensor positioned just above the bolt.

PT

Since the method under development requires extensive data manipulation and computer operation, the mathematics involved will have to be streamlined for greater efficiency, according to Schlyer. Brookhaven, which has expertise in PET scanning and modeling will work on the mathematical calculations required to adapt the detector developed by CTI, Inc., for use in PET. At Brook-haven Lab, researchers also use PET to study changes in the brain related to aging and drug addiction, among other research projects.

Currently, there are more than 250 PET machines at major hospital and research centers around the world. Ronald Nutt, senior vice president of CTI, Inc., commented, "PET is already a powerful imaging tool for diagnosing cancer and other significant diseases .This blood-monitoring system will allow PET to accurately quantify metabolic activity, which can take PET to the next level."

The Brookhaven-CTI team hope to have a working prototype of the blood monitor in the fall of 2000. PT

Not a Cloud in the Sky

Lynx, a fine-resolution, real-time *s*ynthetic-*a*perture *r*adar (SAR) system was recently unveiled by Sandia National Laboratories and General Atomics of San Diego. Designed to be mounted on both manned aircraft and *u*nmanned *a*erial *v*ehicles (UAVs), the 115-pound SAR is a sophisticated all-weather sensor capable of providing photographic-like images in real-time through clouds, rain or fog, and in day light or at night.

The SAR produces images of extremely fine resolution, far surpassing current industry standards. Depending on weather conditions and imaging resolution, the sensor can operate at a range of up to 85km.

"The Lynx represents a breakthrough on many fronts," said Bill Hensley, Sandia project leader. He added, "The real-time, interactive nature of the radar and the innovative operator interface make it a breakthrough for meeting the ease-of-use needs of front-line military users. And because Sandia developed the technology and successfully transferred it to General Atomics, the Lynx radar also is a technology-transfer success story."

Mike Reed, Lynx program manager at General Atomics, said that Sandia and General Atomics joined forces in 1996. General Atomics and Sandia spent the next three years refining and enhancing the SAR into a lightweight, user-friendly system with extended range and much higher resolution. The new SAR will enhance the surveillance capability of the General Atomics Aeronautical Systems UAVs and other reconnaissance aircraft, which previously were equipped only with cameras, IR sensors, and older-generation SAR equipment.

"Cameras provided good data, but they don't work at night or in rainy, foggy, and cloudy situations," Hensley said. "Fine-resolution-image SAR radar is perfect for these circumstances because it can 'see' in the dark and peer through clouds and fog."

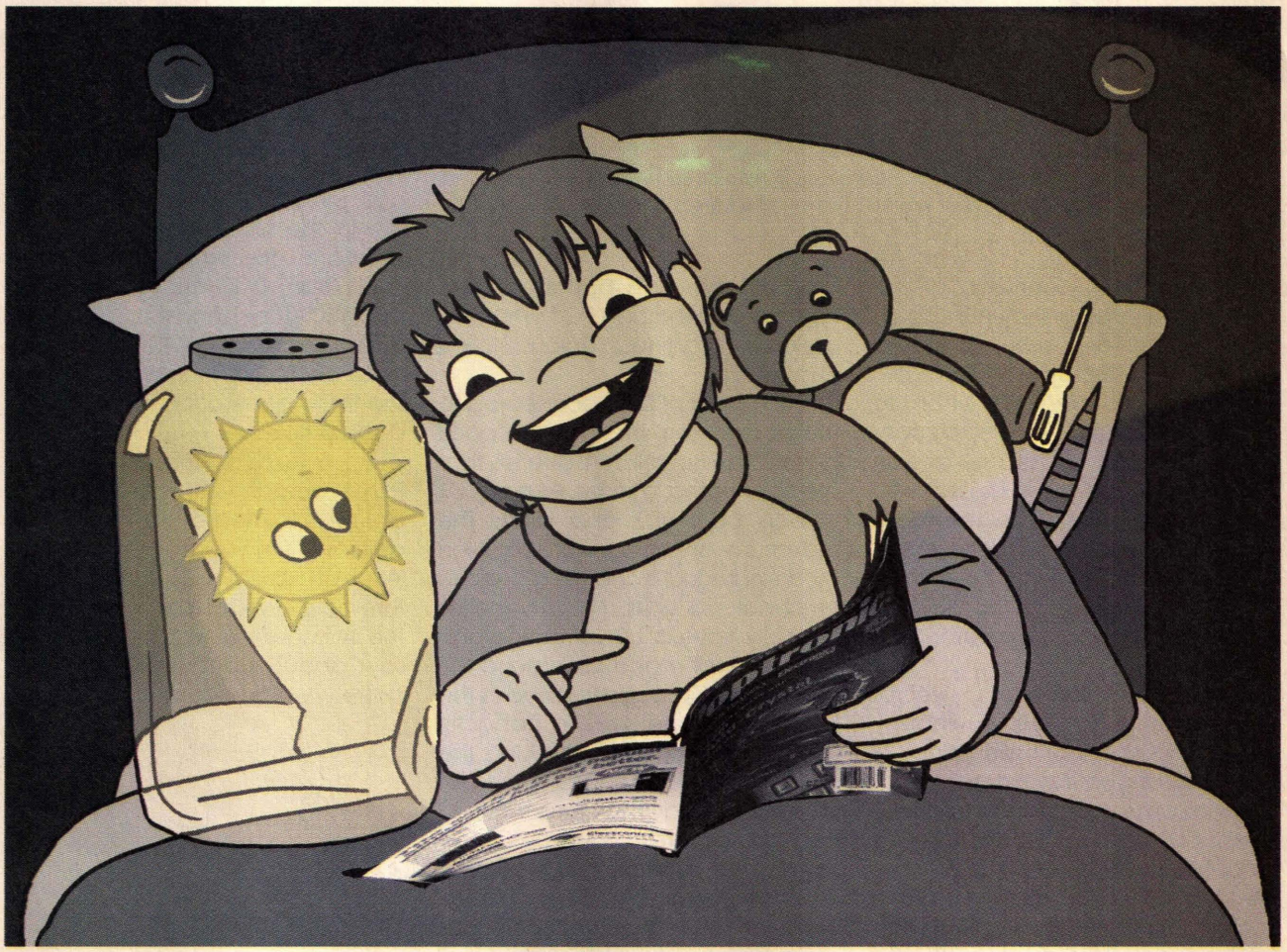
Flying at altitudes of 25,000 feet, the Lynx SAR can produce one-foot-resolution imagery at standoff distances of up to 55km. At a resolution of four inches, the radar can make images of scenes 25 km away (about 16 miles) even through clouds and light rain. Lynx has been flown successfully for more than 140 hours on a Department of Energy (DOE) plane and on the General Atomics I-GNAT, with SAR providing the precision expected.

Sandia researcher Bill Hensley checks the Lynx SAR installed on a General Atomics I-GNAT unmanned aerial vehicle. (Photo by Randy Montoya)

The radar operates in Ku band with a center frequency of about 16.7 GHz, although the precise value can be tuned to prevent interference with other emitters. It forms an image covering an area larger than that displayed, an image that is stored in cache memory. This allows the operator to pan around within the total scene to concentrate on a particular area of interest. The radar's fine resolution allows it to detect small surface penetrations—even footprints in a soft terrain.

Future upgrades could include an inverse SAR mode for imaging of seaborne targets, interferometric SAR (requiring the use of two antennas) for 3-D imaging, the ability to cue other sensors, and radio-frequency tagging—both for combat identification and for precision-strike applications. PT

Nocturnal Flame



JON J. VARTERESIAN

Capture the sun's light to use when you need it most—at night!

Since the dawn of civilization, man has always looked for ways to push back the darkness of night. Ways to help him see in the dark have progressed from flame torches and oil lamps to the most sophisticated halogen and high-intensity-discharge lighting systems of the modern age. Even today, that age-old problem manifests itself in trying to light the patio, deck, walkway, or steps around your house at night. Fancy lighting schemes and the resulting complicated outdoor wiring tend to be overkill—much like using a shotgun to swat a fly.

What we need is a lighting system that can provide enough light at night so that we don't trip over an obstacle in our path. Note that "enough light" doesn't necessarily mean sufficient light for reading or similar activities. While our eyes don't have the ability to work in near-total darkness like those of a cat or fox, surprisingly little light in the right spectrum is needed for us to discern objects; just a shadowy outline is enough for our brains to reconstruct what's out there.

The *Nocturnal Flame* presented here is just the device to shed some light on that problem. A PIC-microcontroller-based solar-powered accent light, it charges three AA-sized NiCd batteries during daylight and turns on a high-brightness light-emitting diode (LED) at night. Adjustments control the brightness of the LED and the light level at which it turns on.

Not only is the Nocturnal Flame a fun project to build, it also teaches solar-power technologies and microcontroller-programming skills. Although some might say that using a microcontroller for such a simple function is going overboard, it is much easier to change parameters in the software instead of tearing apart large sections of circuitry and rebuilding it should you wish to modify how the unit works.

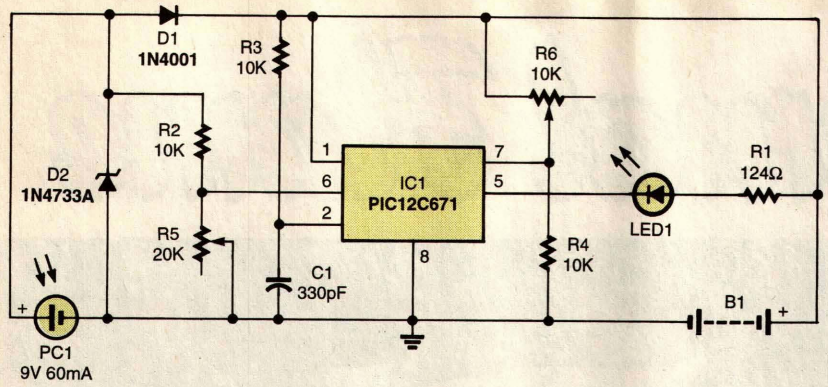


Fig. 1. The Nocturnal Flame is a simple monitor circuit that uses a solar cell to recharge a set of NiCd batteries during the day. At night when the output of PC1 drops below a set point, LED1 is turned on.

Hardware. The schematic of the Nocturnal Flame is shown in Fig. 1. The heart of the circuit is IC1, a PIC12C671 microcontroller. The PIC's software decides when to turn LED1 on or off as well as controlling the amount of power that LED1 consumes. While IC1 is designed to run on 3 to 5.5 volts, the maximum voltage that it sees is 4.4 volts—more on that in a moment.

The combination of R3 and C1 form a 250-kHz RC oscillator that runs IC1.

Solar cell PC1 provides power for the Nocturnal Flame from whatever light source you'll be using. In case you are not familiar with solar technology, a solar cell produces electrical power when light is applied to it. Certain cells are designed to work best in natural sunlight, others in artificial light such as the fluorescent or incandescent type. The cell specified for PC1 is the natural-sunlight type.

Zener diode D2, a 1N4733, limits PC1's maximum output voltage to 5.1 volts. That ensures that the NiCd battery pack B1 does not see too high a charging voltage; voltage to IC1 is also limited. The maximum voltage is 5.1 volts (the Zener "knee" voltage of D2) minus the voltage drop across D1: 5.1 – 0.7, or 4.4 volts. If PC1 tries to produce a voltage greater than 5.1 volts, D2 begins shunting the excess current to ground, lowering PC1's voltage. Zener diode D3's one-watt power rating limits the current flow through it to 196 milliamps. Keep that limit in mind if you decide to use a different cell than the suggested unit.

In addition to its forward voltage drop, D1 prevents battery current from flowing through PC1 when it is dark out, wasting precious stored energy.

The output of D1 is connected to the positive terminal of B1, a pack of three AA-size NiCd batteries that are connected in series. At night, B1 powers both IC1 and LED1. The maximum charging voltage seen by an individual battery is (5.1–0.7)/3 or about 1.5 volts. NiCd batteries typically have a 1.2-volt rating and like to be charged at around 1.5 volts. The NiCd batteries used in the Nocturnal Flame have a capacity rating of 0.6 amp-hours. Using the standard 10-hour charging rule of thumb, the charging current should be somewhere around 60 milliamps, the maximum current that PC1 can supply. If you use a different solar cell, make sure that it does not supply too much current (over 300 milliamps) or you will damage the batteries.

Pin 5 of IC1 is used to turn LED1 on and off; a logic low (ground) lights the device. Resistor R1, a 124-ohm unit, limits the maximum current through LED1 to around 25 milliamps.

Pulse-width modulation (PWM) is used to limit LED1's power, and thus control its brightness. By limiting LED1's power consumption, battery life is increased, which lets the Nocturnal Flame operate throughout the night. The technique can be applied to almost any battery-powered application.

Figure 2 shows a typical PWM signal. The *period* is the cycle time in Hertz. For the 15-millisecond length used in the Nocturnal Flame, the period is 1/15 milliseconds, or 66.67 Hz. The *duty cycle* is the ratio of the "on" time divided by the "off" time for a given period. The signal shown in Fig. 2 has a duty cycle of 2 mS/15 mS or 13.33%. Note that the "on" time may be defined as either the low or high portion of the signal depending on your application; the Nocturnal Flame uses the low portion by design.

As long as you pulse the current to LED1 faster than about 60 times a second (a 60-Hz period), your eyes will not see the pulsing—it will appear as if LED1 is continuously on. In the Nocturnal Flame, IC1's software can generate a duty cycle from 0/15 mS (0%) to 15/15 mS (100%) in 1-mS steps. That lets the brightness of LED1 be set to one of 16 discrete levels. We'll describe the PWM generation in detail later in this article.

Pin 6 of IC1 is used to monitor PC1's output voltage. A voltage divider is formed by R2 and R5. By adjusting R5, you can set the light level at which LED1 turns on. The threshold level at pin 6 for making the switch is below about 53 mV. I say "about" because IC1 uses the battery voltage as a reference for

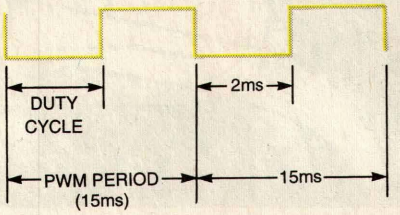


Fig. 2. In pulse-width-modulation (PWM) control, a pulse is repeated at intervals; the length of the pulse determines how much power gets through. In this example, we're interested in the low portion of the pulse. A 2-mS pulse repeating at 15-mS intervals yields a 13% duty cycle.

its internal analog-to-digital conversions; freshly charged batteries will have a higher output voltage than used batteries.

The LED will not turn off again until the voltage on pin 6 rises above 85 mV. The 32 mV of hysteresis ensures that LED1 does not unintentionally oscillate on and off. Figure 3 details the on-and-off hysteresis-transfer function.

Pin 7 of IC1 senses the brightness control for LED1. Again, a voltage divider is used: R4 and R6. By adjusting R6, the voltage on pin 7 can range

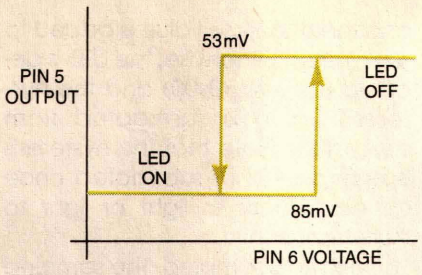


Fig. 3. To keep LED1 from flashing and flickering from slight variations in PC1's output due to shadows or other temporary dips in output, hysteresis is designed into the Nocturnal Flame's software. In this example, LED1 won't turn on until PC1's output drops below 53 mV. Once that happens, LED1 won't turn off until the voltage rises to 85 mV.

from full battery voltage down to about half. At the low end, LED1 will be completely off. Higher voltages select one of the 15 additional levels of brightness, with full on when pin 7 is at full battery voltage.

Software. If the heart of the Nocturnal Flame is IC1, then the software that resides within that chip is its brain. A flowchart that the software was designed around is shown in Fig. 4. As we study how the software works in conjunction with the hardware around it, you'll see examples of pulse-width-modulation control, simple interrupt handling, timer operation, and general input/output (I/O) manipulation. The skills learned will let you tackle a wide range of embedded-control design tasks with other projects.

When power is first applied to IC1, the software begins by configuring all of the I/O ports and peripherals such as the analog-digital converter and internal timers. The software variables used by the program are also created and preset at this time.

The PIC then waits in an endless loop for the TIMER0 interrupt. That timer expires once every millisecond, generating an interrupt signal to the CPU. With each interrupt, the PIC jumps to the interrupt handler in order to service the interrupt.

The interrupt handler's job is to pulse-width modulate LED1, sample the solar cell's output voltage to determine whether it is light or dark out, and sample R6 to determine how bright LED1 should be. Once the interrupt-handler's job is complete, the PIC returns to the endless loop waiting for the next one-millisecond interrupt.

The Nocturnal Flame uses six software variables to control the different hardware functions. Before we take a closer look at the one-millisecond interrupt-service routine, let's define those variables:

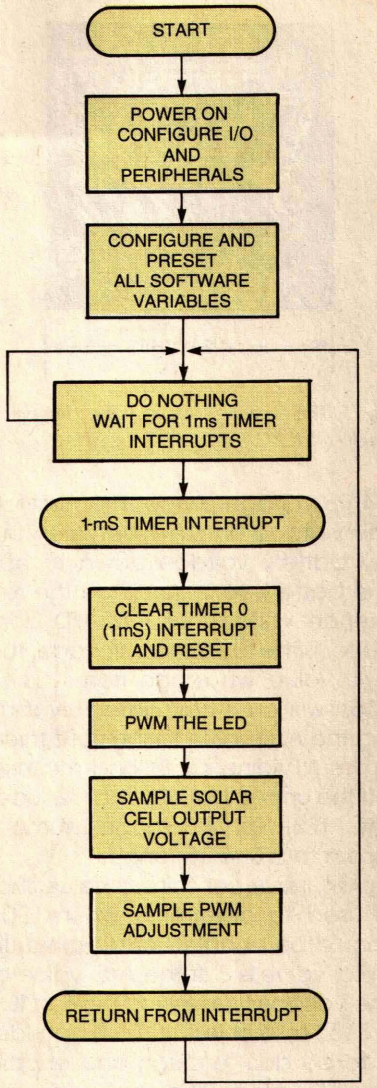


Fig. 4. The Nocturnal Flame software is an endless loop that can only be exited by a timer-generated interrupt. The interrupt-service routine handles all of the Nocturnal Flame's features. Once the routine finishes its work, program execution goes back to the endless loop waiting for the next interrupt.

• LED_CURR contains the current value of LED1's pulse-width-modulation period. In order to know when to turn LED1 on and off within the 15-mS period, we have to keep track of the millisecond ticks as they occur. This variable counts from 0 to 15 in synch with each interrupt.

• PWM_ON contains a number from 0 to 15 that describes the desired PWM duty cycle in milliseconds. A zero means "off" (0 mS) and 15 is fully on (15 mS). The value is taken by measuring the voltage on pin 7 of IC1 with the internal A/D converter. That voltage, as we discussed before, comes from the

PARTS LIST FOR THE NOCTURNAL FLAME

SEMICONDUCTORS
IC1—PIC12C671 microcontroller, integrated circuit
LED1—Light-emitting diode, high-brightness
D1—1N4001 silicon diode
D2—1N4733A Zener diode

RESISTORS
(All resistors are ¼-watt, 1%, metal-film units unless otherwise noted.)
R1—124-ohm
R2–R4—10,000-ohm
R5—20,000-ohm potentiometer, PC-mount
R6—10,000-ohm potentiometer, PC-mount

ADDITIONAL PARTS AND MATERIALS
B1—NiCd battery, 3.75 volts, 650-milliamp-hour
C1—330-pF, ceramic-disc capacitor
PC1—Photovoltaic panel, 9-volt, 60-mA (All Electronics SPL-960 or similar)
Battery holder, IC socket, wire, hardware, etc.

Note: The following items are available from JV Enterprises, PO Box 370, Hubbardston, MA 01452; 617-803-3832; *JVEnterprises@worldnet.att.net*: Kit of all components including preprogrammed IC1, etched, drilled, and tinned PC board, PC1, B1, and complete documentation, $38; partial kit that does not include PC1 or B1, $20; PC1, $8; etched, drilled, and tinned printed-circuit board, $4.50; preprogrammed IC1 with source code and documentation, $10. Please add $3 for shipping and handling. MA residents must add appropriate sales tax. Personal check, money order, Visa, MasterCard, Discover, and phone orders accepted.

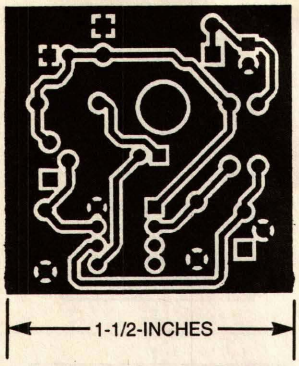


Fig. 5. The Nocturnal Flame is best built on a single-sided PC board to reduce wiring errors.

R4/R6 voltage divider that restricts the voltage on pin 7 between the full battery voltage down to half the battery voltage. Since the reference voltage of the A/D converter is the full battery voltage, the A/D value will range from 128 to 256. PWM_ON is calculated by shifting the A/D value to the right three times (dividing by 8) and masking off the upper four bits. That reduces the 128- to 255-range number down to a 0 to 15 range.

• DARK_THRESH contains a value that is used to determine when LED1 should be enabled or disabled. Its initial value is 3. If the A/D value of the voltage present on pin 6 of IC1 is 3 (53 mV) or less, IC1 will consider it to be dark enough and enable the LED. The PIC also adds the value specified in DARK_HYSTER to DARK_THRESH to ensure the LED will not be enabled or disabled very quickly when the solar cells output slowly passes the DARK_THRESH value. In order for the LED to be disabled, the A/D value of the voltage present on pin 6 of IC1 must rise above 5 (85 mV). When it does, LED1 is disabled, and the DARK_HYSTER is subtracted from DARK_THRESH.

• DARK_HYSTER contains a value that is used to remove "jitter" from the on/off control of LED1. As described above, it works in conjunction with DARK_THRESH to ensure that the LED will not be enabled and disabled very quickly when the solar cells output slowly passes the DARK_THRESH value. Note that DARK_HYSTER isn't really a variable since its value doesn't change dynamically; the proper name for it would be a *constant*.

• LED_STATE contains the current state of the LED. If the value is 0x00, the LED is disabled and will be turned off. If the value is 0x01, the LED is enabled and will be turned on.

• TMR0_CNT is used to count 0.256-second periods in millisecond steps. It is incremented every time the interrupt service routine is called. When it rolls over from 0xFF to 0x00, PC1 and R6 are sampled. In that way, you only look at those inputs every / second or so—close enough for an LED.

The interrupt routing starts by checking to see if LED1 is enabled. If it is not enabled, it is turned off, LED_CURR is cleared, and the routing exits. If LED1 is enabled, the routine checks to see if PWM_ON is less than or equal to LED_CURR. If it is, LED1 is turned on; if not, the LED is turned off. For example, if the PWM_ON value is set to 5, the LED would be on when LED_CURR is anywhere between 0 and 5, and off when the counter reads between 6 and 15, effectively generating a modulated signal. Next, LED_CURR is incremented; if the count rolls past 15, it is reset to zero.

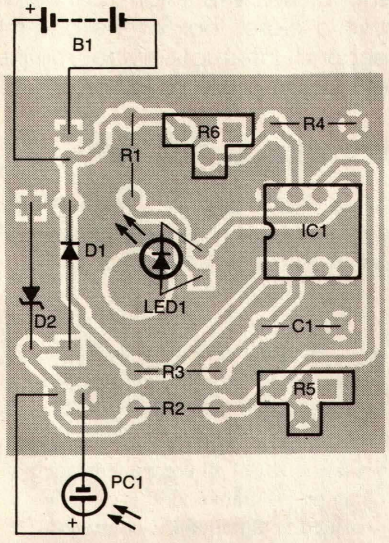


Fig. 6. The Nocturnal Flame circuit is so simple, you don't need any jumper wires on its single-sided board.

Now that the LED has been serviced, TMR0_CNT is checked. When that counter overflows, 0.256 seconds has elapsed; time to check PC1 and R6. The solar cell is sampled first. If the sampled A/D value is less than or equal to DARK_THRESH, the LED is enabled (LED_STATE=0x01) and the hysteresis value is added to DARK_THRESH. Otherwise, the LED is disabled (LED_STATE=0x00) and the hysteresis value is subtracted from DARK_THRESH. Note that the hysteresis is only added or subtracted once for each dark to light or light to dark transition.

Next, R6 is sampled. The sampled A/D value is checked to see if it is less than 128. If so, the result is reset to 128. That is done to make sure that the sampled value is within the range of 128 to 255 or the PWM_ON value might be incorrect. The sampled A/D value could drop below 128 due to the tolerance of R4's and R6's values. Once PWM_ON has a value between 0 and 15, the interrupt routine returns to the endless loop to wait for the next one-mS tick.

Assembly and Test. The Nocturnal Flame is simple enough to be built on a piece of perfboard using standard construction techniques. However, a neater and more error-proof project results from the use of a PC board. If you'd like to go that route, a foil pattern for a single-sided board is shown in Fig. 5. As an alternative to etching your own board, one can be purchased from the source given in the Parts List.

If you are using a purchased or self-etched board, use the parts-placement diagram in Fig. 6 to locate where the components should go.

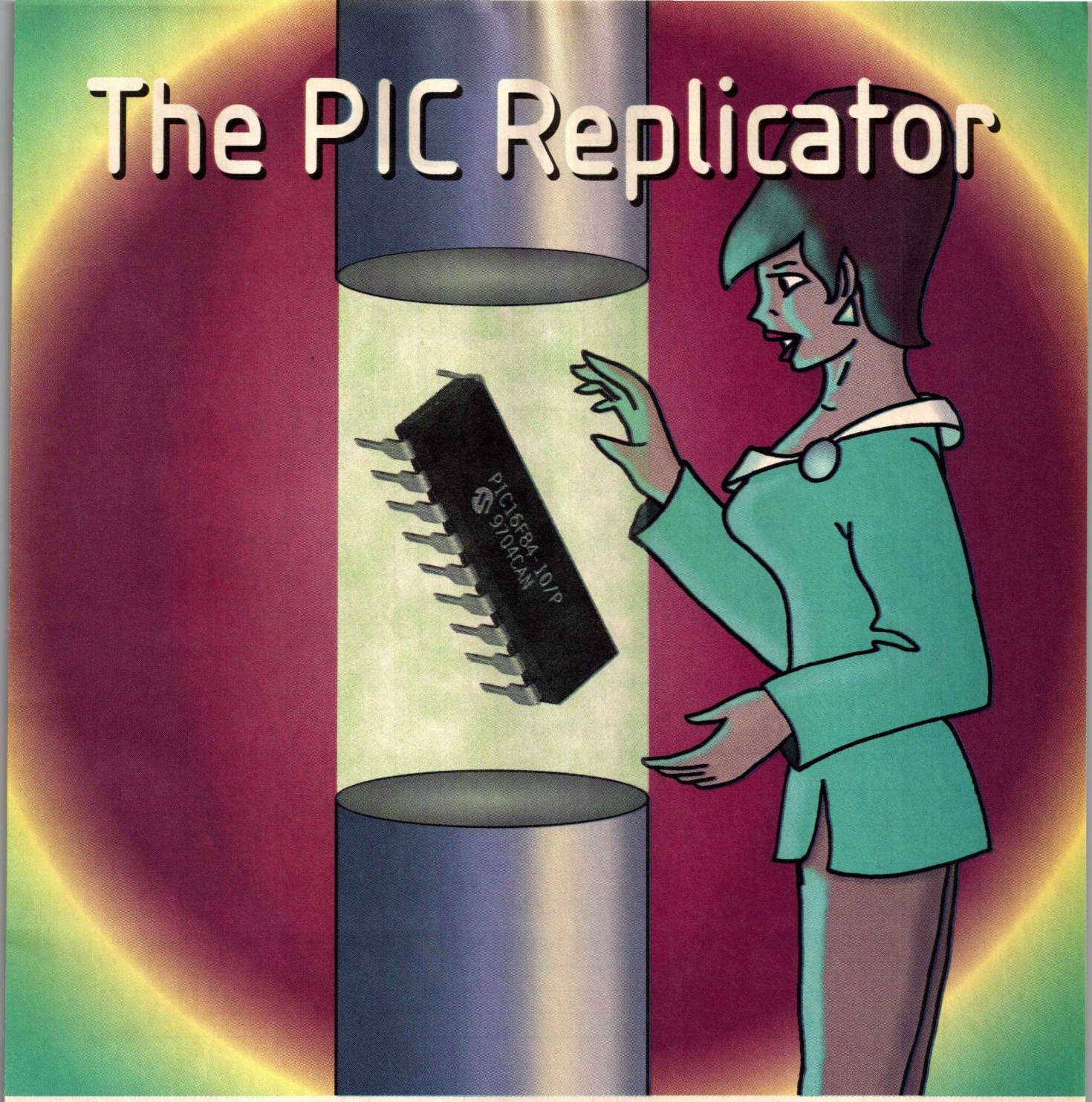
When assembling the board, double-check the polarity of the semiconductors before soldering them. Note the position of the notch for IC1. In fact, it's a good idea to use a socket instead of soldering the integrated circuit directly to the board. That way, you can easily change the microcontroller if you want to try a different program.

Before installing it in the board, IC1 must be programmed with the software that gives the Nocturnal Flame its personality. That software can be found on the **Poptronics** FTP site at *ftp.gernsback.com/pub/pop/nocturnal_flame.zip*.

The solar cell used in the author's prototype came without attached wires; channel-shaped clips were provided instead. To assemble that

(Continued on page 65)

The PIC Replicator



Want to program PICs, but you don't have the required hardware? Here's a programmer that doesn't require a programmer to build. What's more, you can update the unit's software to take advantage of future developments in programmable microcontrollers

PETER BEST

Microchip's PIC microcontroller—cheap, easy to find, easy to program, and easy to use—is probably the most popular microcontroller in the world today. Relatively simple to implement, the only complexity that PICs have are the many available variants.

If you use or plan to use differing types of PICs, supporting their different requirements on the programming-hardware side can get expensive. For most of these programmers, a base unit needs a separate plug-in module for each PIC type to be programmed. The other end of the PIC-programmer spectrum is the really cheap unit that will empty your pockets by requiring software upgrades, special adapter sockets, and cables for each additional part to be programmed.

With thousands of engineers, designers, and hobbyists discovering the power of the PIC daily, many are waiting for a inexpensive but viable PIC programming platform—and

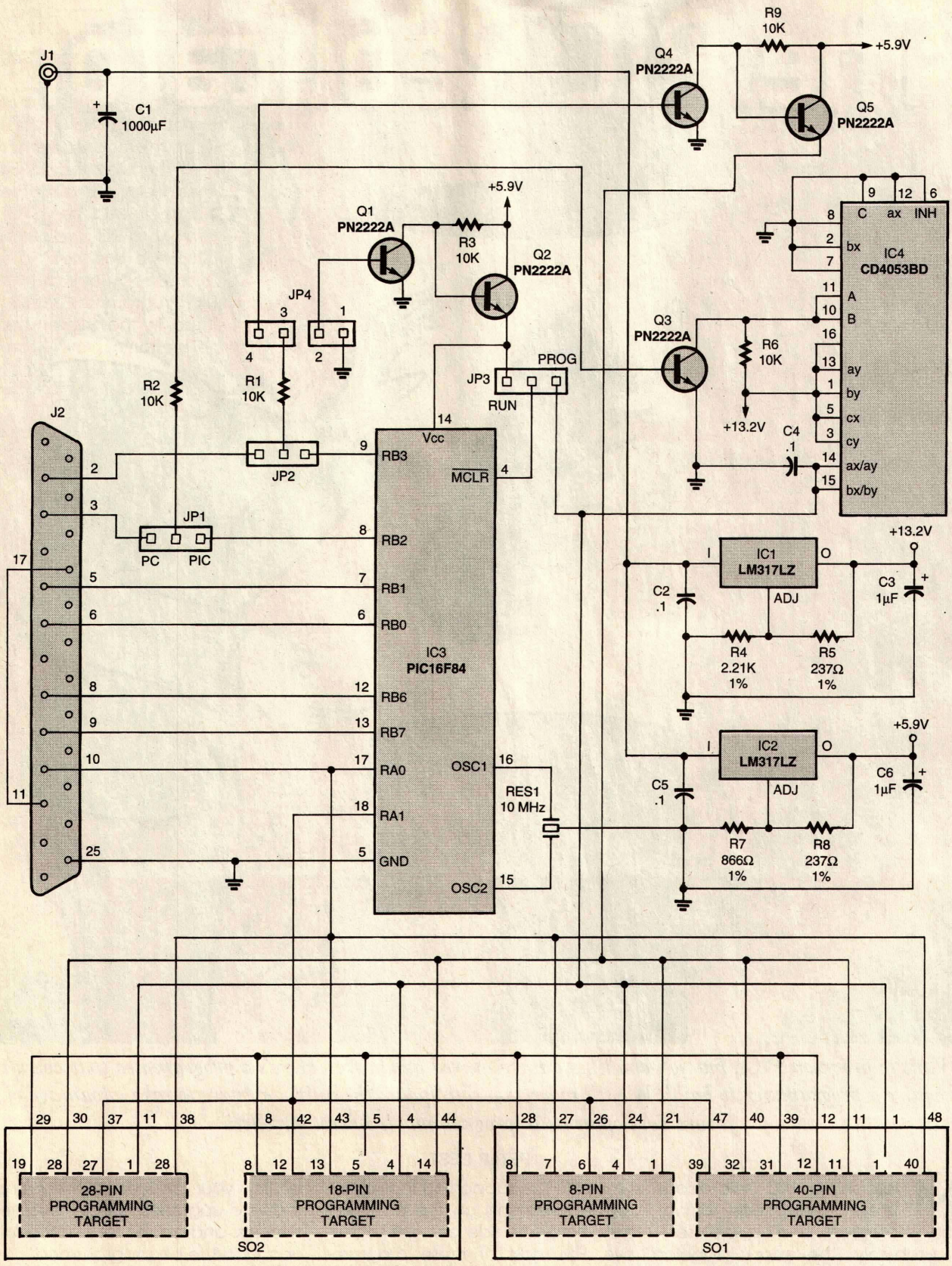


Fig. 1. Like many "intelligent" programmers, the PIC Replicator is built around a PIC microcontroller. However, by setting jumpers JP1–JP4 to the appropriate settings, you can use the basic hardware and host software running on a PC to program the controller. If you have the skill, you can even modify the controller's software to suit your needs.

someone's got to help these folks get started on the right foot!

The "perfect" PIC programmer would be able to program most (if not all) of the PICs currently available. It should be inexpensive, easy to build, and, best of all, easy to maintain. By that we mean you should be able to update and customize its functionality to take advantage of future PIC developments. Nothing can be quite as frustrating as investing time and money into a piece of equipment only to see it become obsolete in a matter of months or weeks!

To that end, we are proud to present the *PIC Replicator*. It has been designed for people who like to fool around with microprocessors like the PIC without burning a hole in their wallet. With about an hour's worth of construction effort, you'll be able to program and read all of the serially-programmable PICs such as the 12C5xx, 12C67x, 12CE67x, 16C6x/7x/9xx, and 16C8x/16F8x PIC devices either in or out of circuit. No special integrated circuits are required and all the parts are common off-the-shelf types that can be obtained from the various advertisers in this magazine. With this low-cost device, you can program your code into at least 40 different types of PICs, including the full line of the exciting new 8-pin "baby PICs."

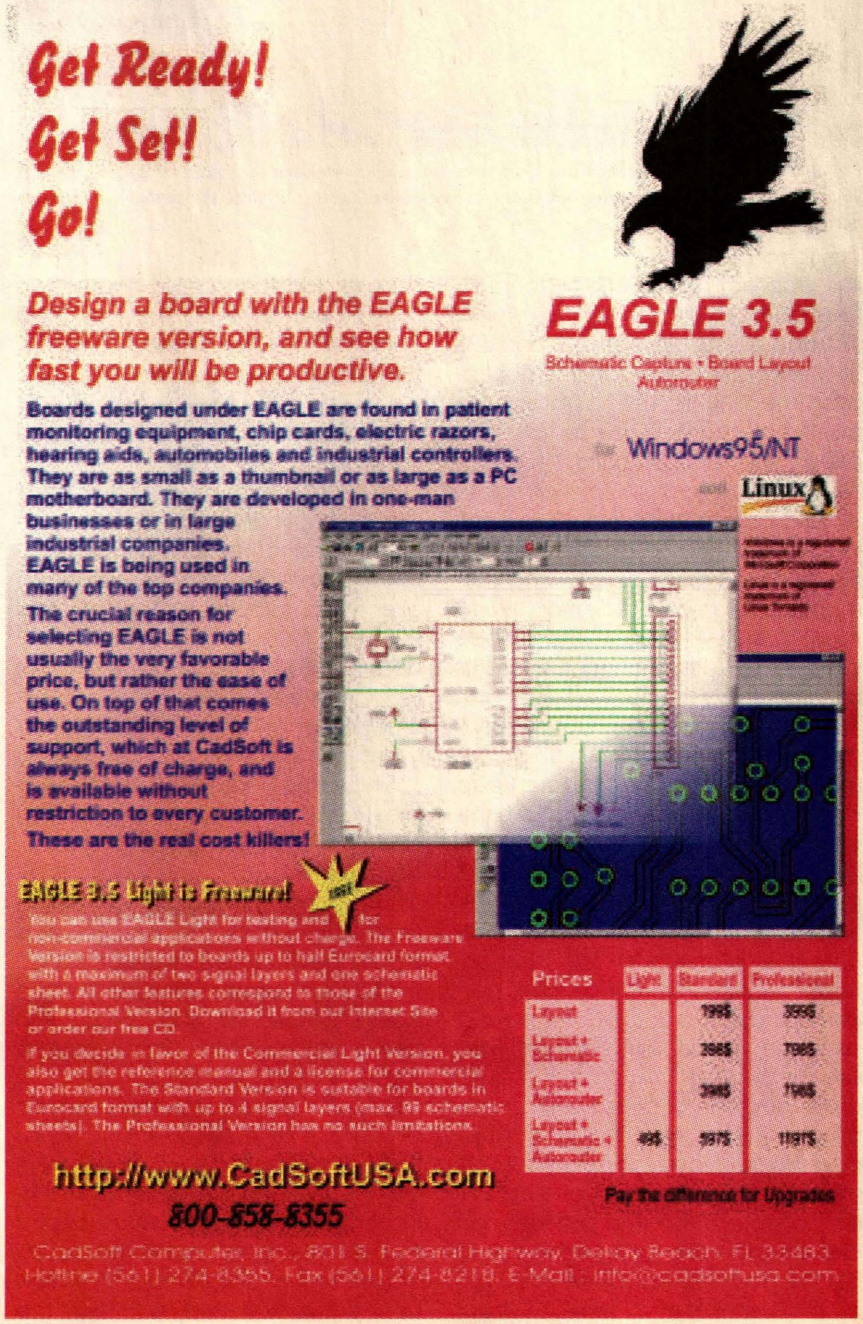
Have special programming needs? No problem—you have full access to all of the project's source code in addition to the hardware schematics. The PIC Replicator is not locked into a single mode of operation. While it uses a preprogrammed microcontroller for on-board "intelligence," the best part is that the PIC Replicator can program its own controller! In fact, it was designed around the "catch-22" situation of "how do you program a programming controller when you don't have a programmer to start with?" For a custom need or to simply support a new type of PIC in the future, simply modify the PIC Replicator source code, compile it, and reprogram the on-board controller.

How It Works. The PIC Replicator is really a very simple piece of hardware that can be divided into four major parts: the programmer engine, the 5-volt supply and switch circuit, the 13-volt supply and switch circuit, and the PIC target sockets.

We'll discuss each section in turn. To follow these discussions, refer to the schematic diagram shown in Fig. 1.

There is only one "intelligent" component in the PIC Replicator circuit: IC3, a PIC16F84. The program that is stored inside it is what gives the PIC Replicator its "personality;" we'll talk about that program in a moment. With the proper program, IC3 acts as an interface to the printer port and host software running on the PC. It interprets and transfers data and commands, controls the programming voltages, and controls some aspects of the programming process.

What makes the PIC Replicator different from other programmers is the choice of microcontroller for IC3. Thanks to the way the 16F84 series was designed, it is a simple task to program it with very little hardware beyond a PC and some clever software. To see how little hardware is needed, look at the "No Parts PIC Programmer" article that appeared in the September 1998 issue of **Electronics Now**. A sim-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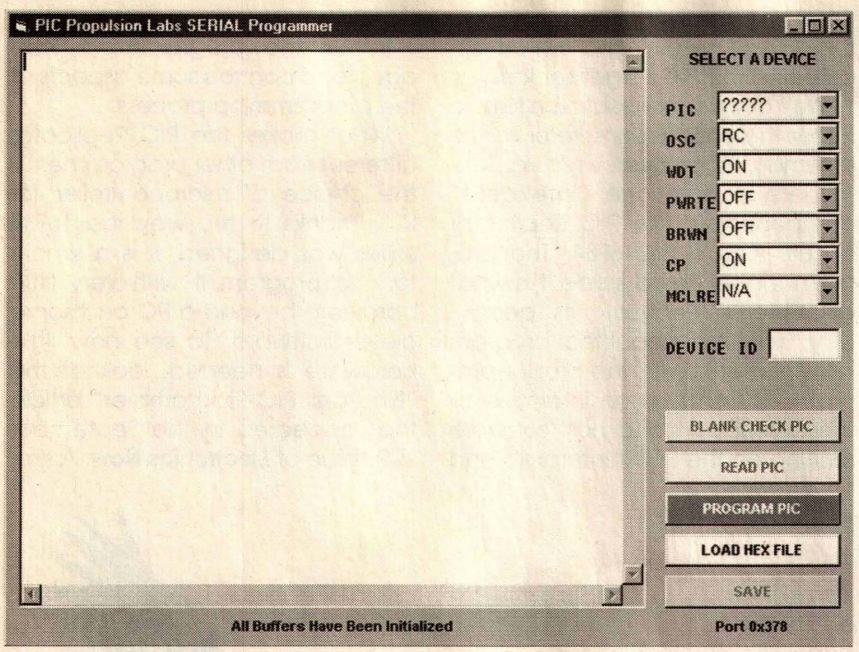

Fig. 2. The PIC Replicator software sports a clean, simple interface that makes it easy to manage your PIC projects. With the click of a button, you can read, write, or check the contents of any supported microcontroller.

ilar approach is used in the PIC Replicator. By setting jumper blocks JP1 and JP2 to "PC CONTROL" and JP3 to "PROGRAM," IC3 can be programmed with the appropriate control program. That way, you can build the programmer without needing access to an already-existing programmer. Normally, having JP3 in the "RUN" position applies 5 volts to pin 4 of IC3, allowing normal operation of IC3. Setting JP3 to the "PROGRAM" position lets us raise pin 4 to 13 volts, putting IC3 into its programming mode.

Pins 6 and 7 of IC3 receive clocked data from J2, which is connected to a PC's printer port. Keep in mind that when we use the printer port to transfer information between the PC and the PIC Replicator, we're sticking with the traditional output-only and input-only lines of the port. The bi-directional features of the parallel port are not used in the PIC Replicator as some of the parallel port lines are dedicated to output functions only. Using the bi-directional capability in that instance could cause port-pin conflicts that could result in unpredictable logic levels and damage to IC3 or the parallel-port circuitry. The big picture here is to use the available hardware resources in their simplest manner without adding additional gates and buffers that would drive up the cost and complexity of the circuit. To sum up the whole idea in a word or two, we're using the basic hardware as is and making the software and firmware do the work.

This approach guarantees that the PIC Replicator is compatible with every type of printer port in existence. While IBM did have fully bi-directional circuitry in their original PC, that feature was not officially documented. That omission put the clone makers in the delicate position of whether to follow the specification or the implemented hardware.

Since the incoming data from the PC is only connected to IC3 and not to the programming sockets, SO1 and SO2, you would think that the incoming clock and data information from the parallel port would be buffered and translated by IC3's internal software before being passed to the target PIC being programmed. That is true to some extent. In reality, the PIC Replicator does not buffer every bit of data that it sees—it only captures data from those pins when commands are being issued to it. Otherwise, the actual values of pins 6 and 7 are read and immediately transferred to pins 17 and 18, which connect to SO1 and SO2. Thus, the data information from the PC program is never captured and is "passed through" to the target as if the parallel-port pins were directly

PARTS LIST FOR THE PIC REPLICATOR

SEMICONDUCTORS

IC1, IC2—LM317LZ adjustable voltage regulator, integrated circuit
IC3—PIC16F84 microcontroller, integrated circuit
IC4—CD4053 analog multiplexor, integrated circuit
Q1–Q5—PN2222A NPN silicon transistor

RESISTORS

(All resistors are ¼-watt, 1% metal-film units unless otherwise noted.)
R1–R3, R6, R9—10,000-ohm, ¼-watt, 5% tolerance
R4—2210-ohm
R5, R8—237-ohm
R7—866-ohm

CAPACITORS

C1—1000-µF, 35-WVDC, electrolytic
C2, C4, C5—0.1-µF, ceramic-disc
C3, C6—1-µF, 16-WVDC, tantalum electrolytic

ADDITIONAL PARTS AND MATERIALS

J1—Co-axial power connector, PC-mount
J2—25-pin connector, PC-mount
JP1–JP3—Jumper pins, 3-position, 0.1-inch spacing
JP4—Jumper pin, 4-position, 0.1-inch spacing
RES1—Ceramic resonator, 10-MHz
SO1, SO2—48-pin zero-insertion-force socket
Jumper blocks, 15-volt DC wall-mounted transformer, IC sockets, wire, hardware, etc.

Note: The following items are available from E D Technical Publications, P.O. Box 541222, Merritt Island, FL 32954; 800-499-3387 (Orders); 321-454-9905 (Technical Support); Fax: 321-454-3198; Web: *www.edtp.com*; e-mail: *peter@edtp.com*: Complete kit of all parts, $89.95; PC board only, $25. Please add $7.50 for shipping and handling on complete kit. MC and VISA are accepted; no COD orders will be filled. FL residents must add appropriate sales tax.

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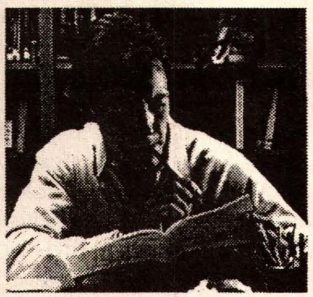

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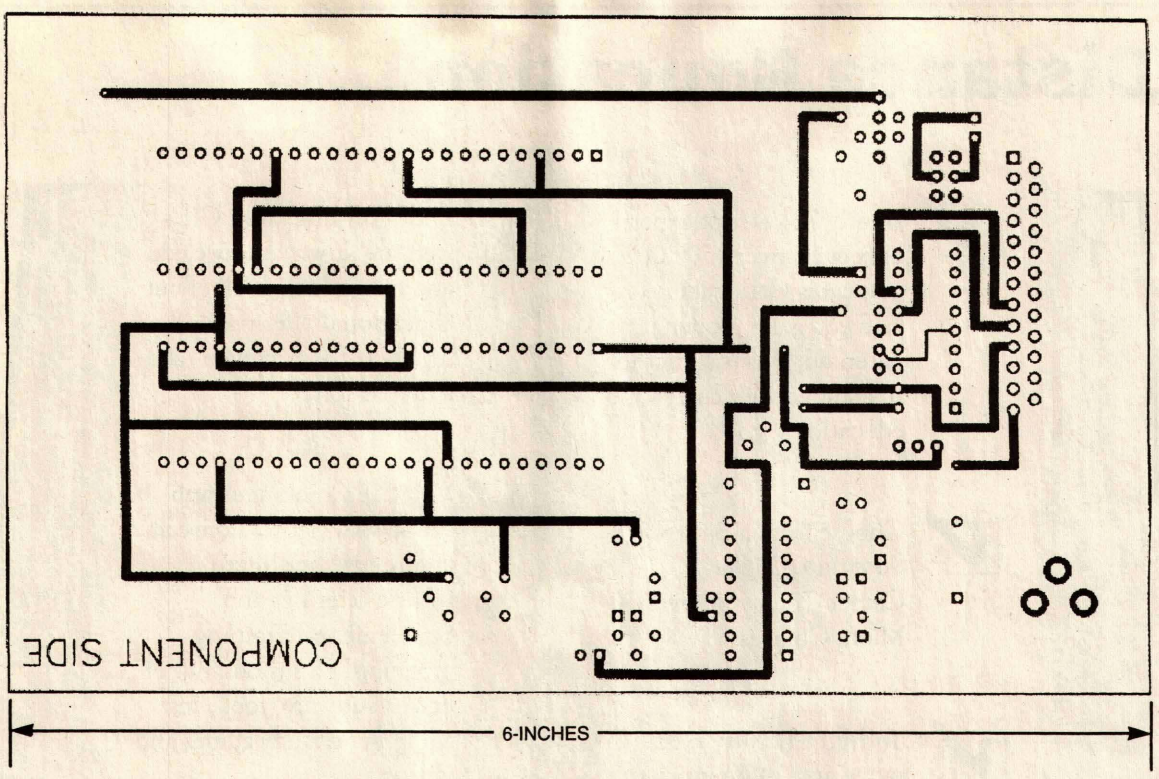


Fig. 3. Although the PIC Replicator can be built on a piece of perfboard, a PC board makes for a more robust unit while reducing wiring errors.

connected to the target sockets. The PIC16F84 with a 10-MHz clock is quick enough to read and transfer the data and clock information to the target PIC without missing any incoming data and clock signals from the PC's parallel port.

When reading information back from a programmed PIC, note that pin 17 of IC3 might cause problems due to conflicting signal levels. The PIC Replicator knows to put that pin in a high-impedance state, called a "tri-state," so that as far as the programmed PIC in SO1 or SO2 and the printer port are concerned, IC3 doesn't exist. The way that the hardware is arranged here, we could use that pin on IC3 to read the incoming data from the target PIC and hold it for later transmission. However, there is no need to do that. Since the PC's host software is reading the data directly from the target PIC, a simple modification of IC3's internal software is all that's necessary.

Powering the PIC Replicator. Overall power for the PIC Replicator is supplied by a 15-volt DC wall-mounted transformer through J1. Capacitor C1 provides some additional filtering. Power is applied to the inputs of IC1 and IC2, a pair of LM317-series adjustable voltage regulators. Precision resistors R4 and R5, along with capacitors C2 and C3, set the output from IC1 to the 13.2 volts needed for programming the microcontrollers.

During normal programming operations, pins 8 and 9 of IC3 control the power sequencing to the target sockets. Logic levels from those pins switch Q3 and Q4, respectively. That control is needed because the power and programming voltages to the PICs being programmed must be switched in a certain order; detailed information on the requirements for a particular microcontroller can be found in its data sheet.

Transistor Q3, along with R6, shifts the logic level from IC3 to allow 0 or 13.2 volts to pass through IC4, a CD4053 CMOS multiplexer. Note that the inputs and outputs of IC4 are connected in parallel to pass the required maximum programming current of 50 milliamps. The CD4053 is a good choice here in that the 0- and 13-volt circuits are completely isolated and there is little if any voltage drop between the chip's input and output pins. Capacitor C4 provides filtering and stability for the 13.2 volts going to the target sockets

Transistor Q4, along with Q5 and R9, switches the 5.9-volt supply generated by IC2, R7, R8, C5, and C6 to the target sockets. If you're wondering why such an "oddball" voltage of 5.9 volts DC is used, remember that the PN2222 transistor used for Q5 is not a perfect electronic device; the transistor's junction resistance will cause a slight voltage drop between the collector and emitter. The goal is to have the transistor switch pair provide a nominal 5.5 volts DC to the target sockets.

In the "replicate" mode, all of the programming voltage switching activity is aimed toward IC3, which could be an unprogrammed microcontroller or one that is about to be electrically erased and reprogrammed. We've already talked a bit about the role of the various jumper blocks; let's look at them in a bit more detail from a voltage-steering point of view.

Under normal conditions, JP4 has a pair of jumper blocks on it that connects R1 to the base of Q4 and grounds the base of Q1. We've

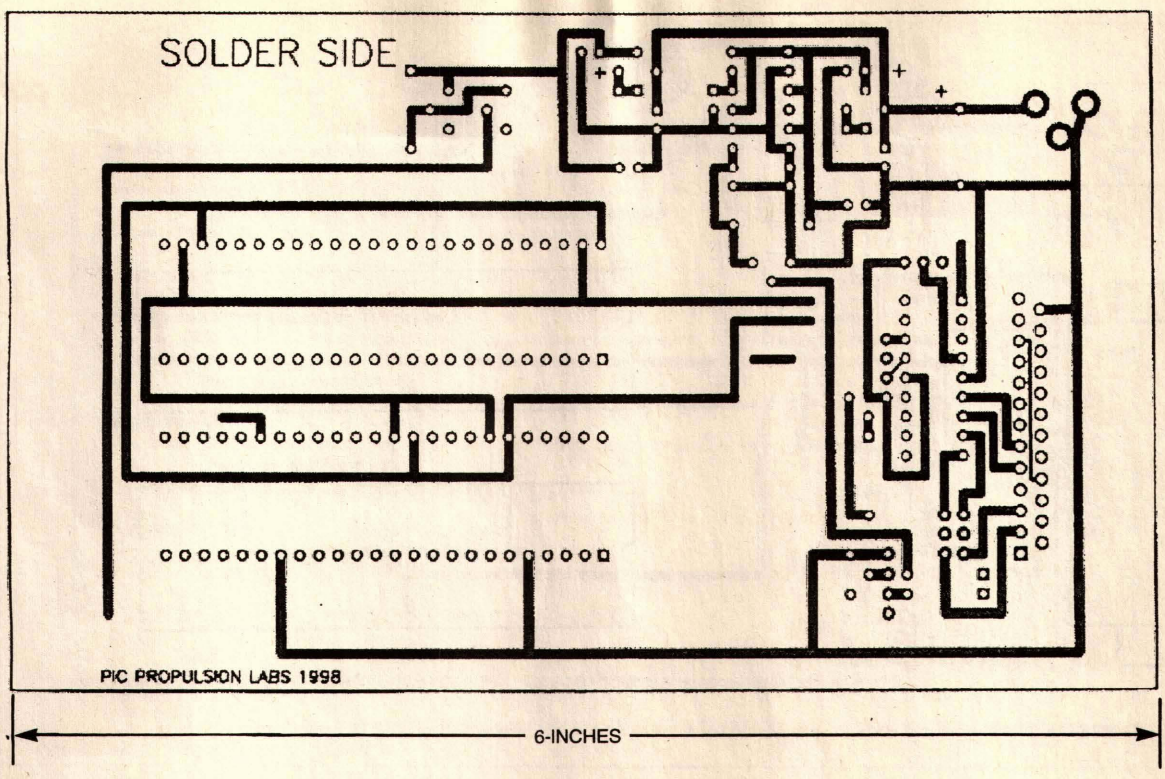


Fig. 4. Here's the foil pattern for the solder side of the PIC Replicator PC board.

already seen how the signal from pin 9 of IC3 passes through JP2, R1, and JP4 to Q4. With Q1's base grounded, it remains cut off, letting the voltage passing through R3 turn on Q2; the result is power for IC3.

During replication, the 5.5-volt DC source and the 13.2-volt programming voltage to IC3 must be controlled. To allow control of the 5.5-volt source, simply remove the two jumper blocks on JP4 and place one across the middle two pins. Note how the logic level from R1 is now applied to the base of Q1. The combination of Q1 and Q2 can now be used to turn the 5.5-volt power to IC3 on and off.

Now that Q1 has control of IC3's power, the next step is to ensure that IC3 itself doesn't try to turn its own power on and off! That is the reason for JP1 and JP2. Switching those jumpers so that the printer port has direct control of R1 and R2 instead of pins 8 and 9 of IC3 ensures that IC3 won't try to accidentally perform "brain surgery" on itself during programming.

The only control left to adjust is to allow 13.2 volts to flow to IC3's reset pin, pin 4. That is done by moving JP3 to the appropriate pins. Normally, JP3 shorts the reset IC3's pin to its power-supply pin. With the jumpers arranged as described, a new IC3 can be created or a current one modified. Moving the jumpers back to their "normal" position makes the PIC Replicator ready to program other microcontrollers in the "socket farm."

The PIC Replicator "Socket Farm." There is no need to go into explicit details on how to program a PIC chip; that information is well documented by Microchip and is available for anyone to download through Microchip's Web site (*www.microchip.com*). Of course, if you want to know what the PIC Replicator's code is doing and why it is doing it, read the Microchip programming specifications. The PIC Replicator's software and firmware was designed using the "development programmer" rules.

You're probably wondering what the PIC Replicator's target sockets has to do with that. It's quite simple: documentation on what signals connect to what pins on the sockets is available in Fig. 1 (how) and Microchip's rules of programming PICs (why). If you consult the Microchip programming specifications and follow the PIC Replicatior's source code, you'll find all of the PIC Replicator signals in their right places being driven by the correct voltages and waveforms.

Note that SO1 and SO2 each serve two types of PIC devices. They are grouped by pin count: 18- and 28-pin devices go with SO1 while 40- and 8-pin devices use SO2. It would be safe to say that, for example, any 18-pin serially-programmed device could go into SO1 at the designated pins and that any 8-pin device could do the same in SO2. To make that a safe bet, you can only select compatible devices from the PC host program. That goes for all of the socket-farm locations. If you need to program parts that are not in the host program's list, consult the appropriate Microchip datasheets for locations of programming voltages and data/clock pins before you attempt to read or program a nonsupported device. Should Microchip modify their programming requirements with future products, you can use the code for IC3 as a basis to do custom coding to handle any new or custom serially-programmable PIC parts.

PIC Replicator Firmware. The

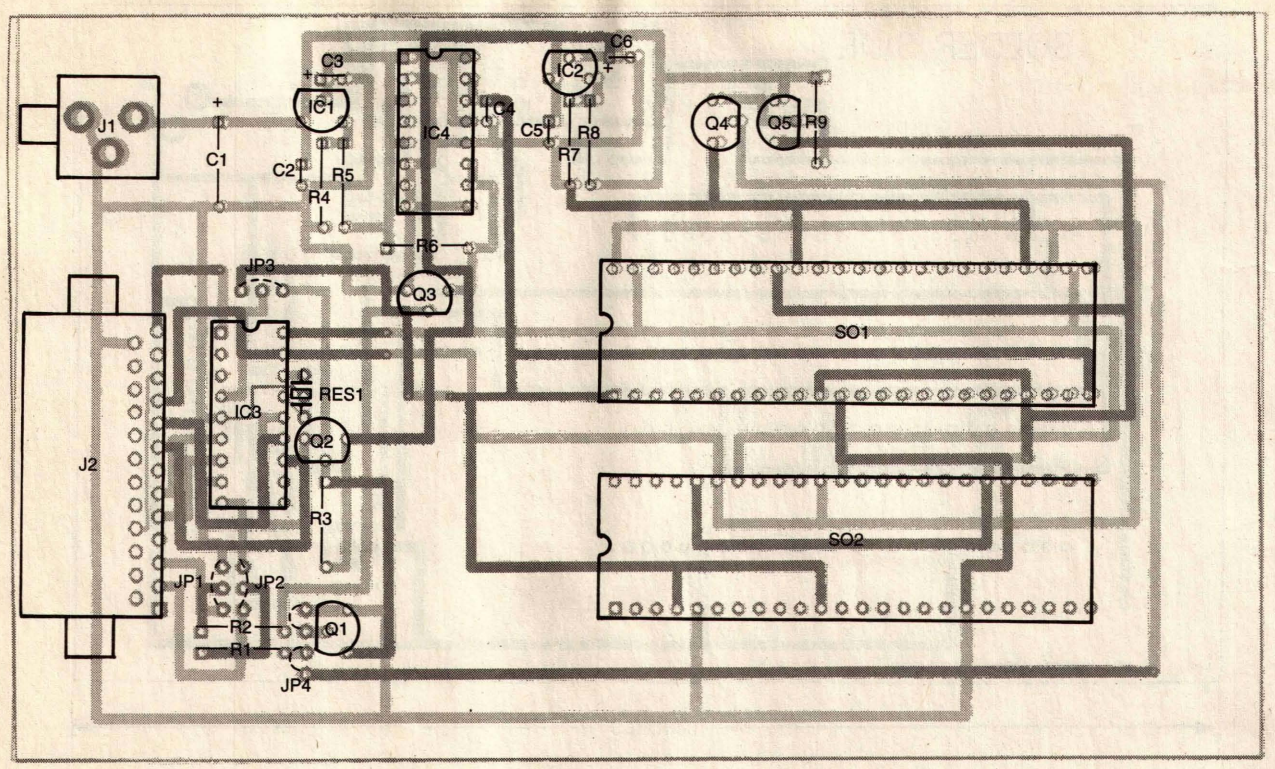


Fig. 5. The PIC Replicator is easily built on a double-sided PC board. The zero-insertion-force (ZIF) "socket farm" lets you program PICs of any size or pin count—including future models.

actual code length for IC3's program is exactly 200 instructions. The source code, as well as the various compiled object code formats, is bundled with the host software. That bundle can be downloaded from the **Poptronics** FTP site; it can be found at *ftp.gernsback.com/pub/pop/pic_replicator.zip*.

The program begins by powering off any target-socket programming voltages that might be present and waits for pin 9 (signifying "power on") from the parallel port to go high. When that happens, the firmware enters an "internal command" mode. Internal commands substitute for using hardwired control bits like the power-on bit we just used. In fact, that power bit could have been implemented as a firmware command as well, but the port pin was available.

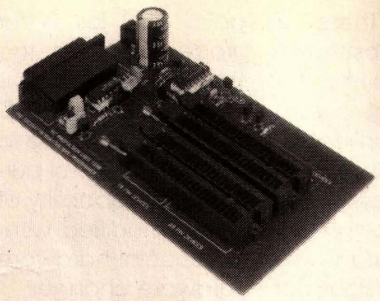
The use of internal commands lets us "talk" to the PIC Replicator firmware before it enters the program/read phase of operation. Thus, we can add commands and control the PIC Replicator at will in that no hardware needs to be added or changed when an internal command is added or deleted. Currently, there are only three internal commands.

Those commands are six bits long and inform the PIC Replicator as to what type of power sequencing to perform. A normal power-up command tells the firmware that when the power bit is high to raise the power voltage to 5.5 volts DC and two milliseconds later to raise the programming voltage to 13.2 volts. That puts most of the parts into what is termed a "test" or "program" mode. The reverse-power-up command is used for the 12C6XXX baby PIC parts only. Those parts require that the programming voltage be raised *before* the power voltage with the same timing and prerequisites as the normal power-up. The final internal command tells the firmware that a "flash" or EEPROM (*E*lectrically *E*rasable *P*rogrammable *R*ead-*O*nly *M*emory) device is mounted in the target socket. The "flash" command tells the firmware to allow 10 milliseconds for the program cycle. Otherwise, the program cycle lasts 100 microseconds. The power-up sequence for the flash command is defined as normal.

After the internal command phase is complete, the firmware enters the "command cycle" phase. This phase constantly monitors the data and clock inputs from the parallel port in search of a six-bit programming command. There are eight commands that can be issued:

- Load Configuration
- Load Data
- Read Data
- Increment Address
- Begin Programming
- End Programming (not used for PIC16X8XX devices)
- Load Data for EEPROM Data Memory (PIC16X8XX only)
- Read Data from EEPROM Data Memory (PIC16X8XX only)

There are actually two more commands: Bulk-Erase Program Memory and Bulk-Erase Data Memory. They are not implemented because the PIC Replicator programs all of the memory area of the PIC16X8XX devices on every program pass. If you need to bulk erase the flash and EEPROM parts, program the parts with a file that



The completed PIC Replicator is not a "dead-end" device—it can be updated and customized as needed.

contains all ones.

The PC Host Software. Written in Visual Basic, the PIC Replicator host program sends commands to and receives data from the target PIC device being programmed through the PIC Replicator hardware. The hardware is invisible as far as the host program is concerned; the host program thinks that it is speaking directly to the target PIC device. To accomplish that, signal timings that cannot be performed by the host program are handled by the PIC Replicator hardware. That technique combined with special software technology in the host software lets the entire PIC Replicator system run on any Windows-based system at any processor speed.

Although we're using a parallel port on a PC, the PIC Replicator software and hardware communicate with each other in a serial fashion. Using a serial port would have added to the complexity of the project—something that we're trying to avoid. Since the PIC Replicator hardware doesn't have any RS-232 conversion ICs or special serial-to-parallel chips (that's done in the PIC Replicator firmware), a "bit-bang" technique is used for communication.

Target PICs were abused unmercifully during the development of the software so that the final product would be smart enough not to let you do so. While we can't guarantee that you won't hurt a PIC at some point either by design or accident, rest assured that the PIC Replicator software will attempt to insure that you don't.

When you start the PIC Replicator host software on your PC, the first task that it does is to look for the PIC Replicator hardware. Note that in the schematic diagram in Fig. 1, pins 11 and 17 of J2 are tied together. It is that short that the host software looks for on every properly installed printer port on the PC. When the PIC hardware is identified, the software will look like the screen shot shown in Fig. 2. As you can see, it is quite simple. All you have to do is select the PIC type and click on a command button. All of the PIC-programmable settings, such as the watchdog timer (WDT), oscillator type (OSC), and so on, should be built into the compiled code that you will be programming into the target PIC; such an arrangement is easy to do when you write your source code under Microchip's program-development software, MPLAB. Those settings are loaded into the PIC Replicator buffers from the file that MPLAB generates during code compilation. While you don't have to use Microchip's software to create your PIC program, using MPLAB eliminates having to manually enter configuration settings into the PIC Replicator host software.

MPLAB has many convenient features such as simulation and error checking; it's a free download that you can get from Microchip's Web site (*www.microchip.com*).

Let's get back to the host software. One of its useful features is performing a "blank check" on a part that the user knows is not blank. Doing this will yield the contents of every non-blank location including the configuration word and the customer i.d. locations. Got a "configuration unknown" PIC? Use the PIC Replicator to read and blank-check it to get the "full Monty" of everything that is stored in it. You can even use the PIC Replicator to "replicate" other non-code-protected PIC parts.

Speaking of replication, the very first action that the PIC Replicator will do is to create its initial programmed IC3. Of course, before you can do that, you have to build the PIC Replicator first.

Assembling the PIC Replicator. This is it—it's time to put the parts together that talk to the software and firmware and bring your PIC Replicator to life. While you can use perfboard and standard construction techniques, a printed-circuit board yields a neater unit with less chance for miswiring errors.

Foil patterns for a PC board are shown in Figs. 3 and 4. If you don't want to attempt to etch a double-sided board, one can be purchased from the source given in the Parts List.

For those assembly methods, follow the parts-placement diagram shown in Fig. 5 for component location. As we build the board we will be testing it; that will help catch mistakes such as wrong parts and components installed backwards before something expensive gets destroyed.

Begin by building up the power-supply regulator circuits. Install J1 and C1, plug in the wall transformer, and test for 15 volts across C1. With the power disconnected and C1 discharged, install the regulator circuits: IC1, IC2, and their associated resistors and capacitors. With power reapplied, you should get 5.9 volts DC from the output of IC2 and +13.2 volts from the output of IC1. Remove power before installing any other parts.

If all is well, install all of the jumpers and assemble the remaining transistor switch pairs and their associated resistors. When it's powered, you should be able to toggle the output voltages of each transistor pair. Apply 5 volts to the base of Q1 through R1. Place a jumper between pins 2 and 3 of JP4 and apply the voltage to the center pin of JP2. The emitter of Q2 (on JP3) should switch to about 5.5 volts. Grounding R1 (jumpering pins 1 and 2 of JP4) should remove that voltage. The same test is done with Q4; a jumper on pins 3 and 4 of JP4 lets you use R1 again. The emitter of Q5 should switch to 5.5 volts in a similar way as before.

Install IC4. Doing the same switching test as before with the base of Q3 (use JP1 and R2 instead) should toggle 13.2 volts at pins 14 and 15 of IC4.

Use a socket to mount RES1—it must be removed when you are programming IC3.

Once you're sure that all of the

voltages are within tolerances and that they can be controlled from both the pins of IC3 and the parallel-port connector pins, mount the remaining sockets and connectors. It is easier to troubleshoot the parallel-port connections and the socket farm before you mount the connector and sockets.

Now we're ready to "burn" the PIC Replicator firmware into IC3. Set JP1 and JP2 to "PC," short pins 2 and 3 of JP4, and set JP3 to "PROG." Remove RES1 and insert a blank PIC16F84 into the socket for IC3. Connect the PIC Replicator to the PC's parallel port with a 25-pin cable; the wires must go "straight through" to all 25 pins.

Start the host program and choose "ENGINE" for the PIC type. On-screen instructions will appear to walk you through the process. It's important that the ENGINE.COD file that was bundled with the software be available; that file contains the actual instructions for IC3.

Once IC3 is programmed, remove power. Set JP1 and JP2 to "PIC," JP3 to "RUN," and two jumpers on pins 1–2 and 3–4 of JP4. Insert RES1 into its socket, and the PIC Replicator is ready to start replicating PICs.

A Quick Review. Let's recap what you now know about the PIC Replicator. Basically, the unit has two modes of operation: "normal" mode in which IC3 is in control of programming and read operations and "replicate" mode that puts a blank PIC16F84 into the socket for IC3 for replication (programming) through the PC's host software and parallel port.

The PIC Replicator is a simple electronic device that depends heavily upon the PC host program and its internal firmware. If you lean towards having the hardware in control, that might be a scary concept for you. The bottom line is that the PIC Replicator hardware is standard stuff and constant. The software and firmware are the variables that make the PIC Replicator useful.

I purposely didn't mention this before, but IC3 can be a PIC16C83, a PIC16C84, a PIC16F84A, a PIC16C61, a PIC16C71, a PIC16C710, a PIC16C711, a PIC16C620, a PIC16C621, or a PIC16C622. Once the initial PIC16F84 is replicated, you can port the source code to any of the above processors with MPLAB, program them with your PIC16F84 version of the PIC Replicator, and plug the newly-programmed PIC into IC3 as the new PIC Replicator engine. In fact, I designed and tested the original PIC Replicator using a PIC16C61 because I didn't have the tools handy for emulating a PIC16F84.

There are gains and losses for substituting processors, but the point is that the PIC Replicator is not a dead-end device. The PIC Replicator was designed to be a low-cost and powerful general-purpose PIC tool with the capability of being upgraded or modified without the need for special hardware or significant hardware changes.

If you have other jobs for the PIC Replicator, all of the programming power you need is located in the socket farm. There's no reason why you could not design a daughter board to plug into SO1 or SO2 that would hold components to interface to other programmable devices. With the PIC Replicator source code and hardware specifications at your disposal, as far as your special PIC Replicator applications are concerned, the sky is the limit.

If you're a beginner to PICs, you have just built a very useful PIC tool that will help you understand all of the nuances of the PIC family as well as provide a means to put your newly-acquired talent to work. If you've been around PICs, the design techniques found in the host software and IC3 firmware might just provide the impetus, and possibly an answer, for that next PIC design.

The specifics of writing PIC programs is beyond the scope of this article. There are not enough pages in this magazine to cover the topic adequately—entire books have been written on the subject. If you need help, there are many sources at your disposal: Internet forums and newsgroups, magazine articles, books, public and university libraries...the list is endless.

If you have any questions concerning the PIC Replicator, the author can be reached through his Web site (*www.edtp.com*). The PIC Replicator PC program has been designed to help you along the way. Don't be surprised if you soon find yourself in the midst of designing that next big "killer PIC project" that just might appear someday in the pages of this magazine

What are you waiting for? A whole new world of microprosessor-based electronics awaits your next discovery! P

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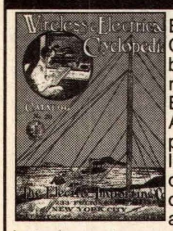

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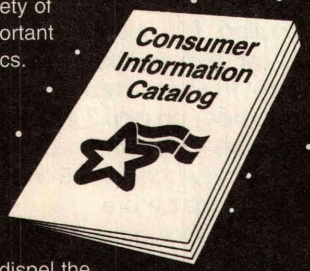

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Two Simple Zener-Diode Testers

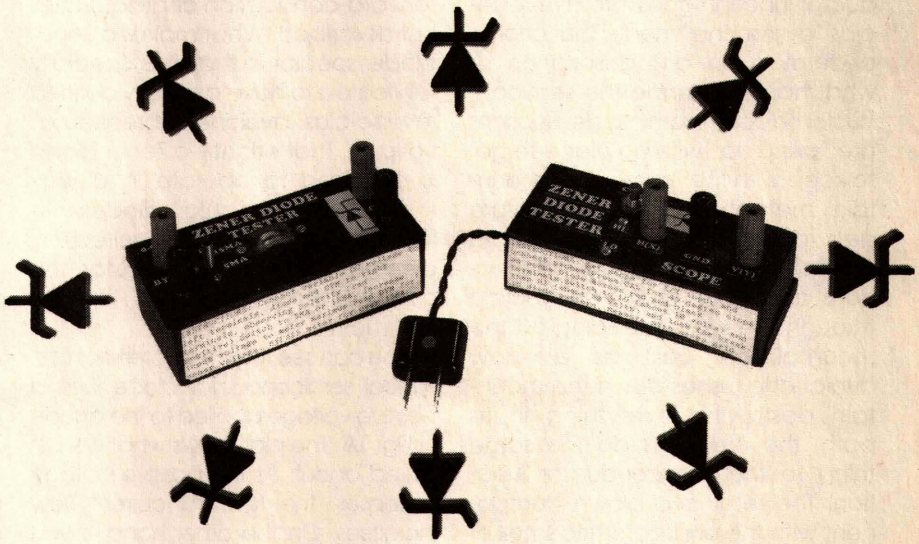
Find out for sure if that Zener diode is or is not working correctly with these handy instruments.

FRED BLECHMAN

Zener diodes are used extensively to provide voltage regulation, clipping, and coupling in various electronic circuits. They are easy to use, but tricky to test. While you can "cobble" together some sort of simple circuit to measure a Zener diode's characteristics when needed, it's always handy to have a simple test jig available. That way you can make those occasional tests without having to scrounge around in your "junk box."

We're going to show you two simple testers that can be used to verify the proper operation of a broad range of Zener diodes. Although you might be thinking, "Oh, great! That's just what I need—another piece of test equipment to clutter up my bench that I'll only use once in a blue moon," we'd like to point out that one of the testers can be used to test various components.

The small amount of bench space that you "sacrifice" will easily pay for itself over and over in time saved trying to isolate a single defective component "needle" in a "haystack" of circuit components.



Zener Diodes. Diodes are about the simplest semiconductor device available. They consist of a simple "p-n" junction formed by two pieces of semiconductor material. One piece (the "p" layer) has more spaces ("holes") for electrons than available particles. Each molecule tries to steal electrons from the one next to it. Free electrons from an electric current are absorbed into the holes and are subsequently stolen by the molecules in need. The net effect is not so much that the electrons flow through the material, but that the *holes* migrate through the structure! The other type (the "n" layer) has extra electrons in its structure that can easily be passed from molecule to molecule like a sub-atomic game of "hot potato;" in that case, it's the electrons that move.

Typically, a diode will conduct current if a voltage higher than the characteristic voltage of the semiconductor material (0.6 volts for silicon) is connected across the device positive voltage to the "p" layer and negative to the "n" layer. The amount of current that a diode can conduct safely depends on the diode's design and rating.

If the voltage is reversed, the diode will block any current from flowing except for a very tiny "leakage" current. As long as the diode's maximum reverse voltage is not exceeded, the device will survive quite nicely. Once that voltage limit is passed, however, the semicon-

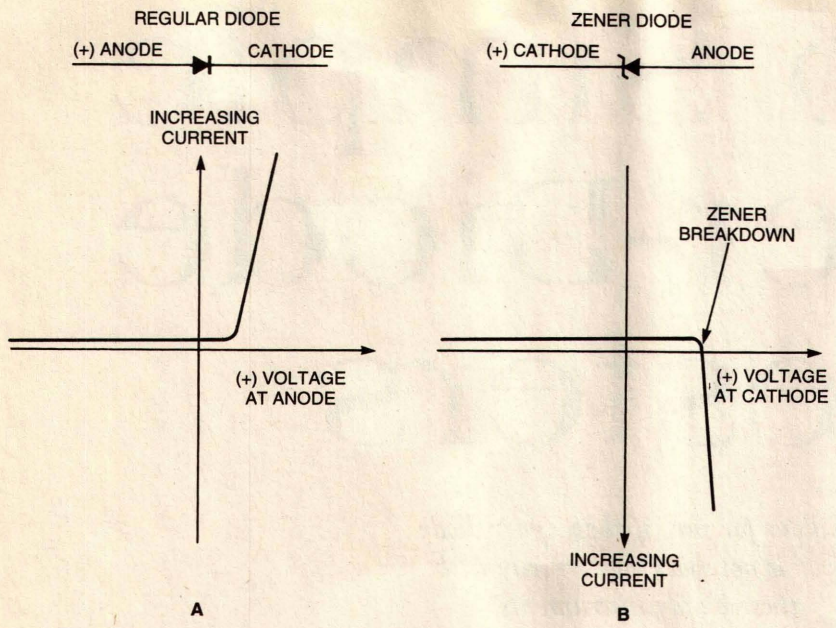


Fig. 1. In both regular and Zener diodes, current flows through the device when the voltage across it reaches a forward-conducting threshold (A). When a reverse voltage is applied, the regular diode blocks any current flow, while the Zener begins conducting when a specific voltage is reached (B).

ductor junction goes into a reverse-bias "avalanche" mode. That choice of term is an apt description of what happens inside the semiconductor on a sub-atomic scale. Electrons are "piling up" with no place to go, to keep with the "snow-on-a-mountain" metaphor. When the pressure gets to be too much and the p-n junction can't hold back the electrons any more, they start pouring through like snow shedding off the mountaintop. Just as a snow avalanche rushes down the mountain destroying everything in its path, the electrons do the same thing to the semiconductor junction. The result is a blown component with the characteristic smell of burned semiconductor and the release of smoke.

A Zener diode is similar is design to a standard diode, including the forward-conduction characteristics just described. What makes a Zener diode special is that it is specially fabricated to have a sharply defined reverse-bias avalanche-breakdown voltage. That's right—a Zener diode is designed to operate in a way that destroys regular diodes. As long as the current is limited by external means, like a resistor, this avalanche breakdown is not destructive.

You can see the characteristics of a typical semiconductor diode with a positive voltage applied to the anode in Fig. 1A. The plot shows what we just talked about: As the positive voltage increases, the forward current flow increases. On the other hand, if you apply negative voltage no significant current flows until you exceed the voltage rating of the diode and it "avalanches" to destruction.

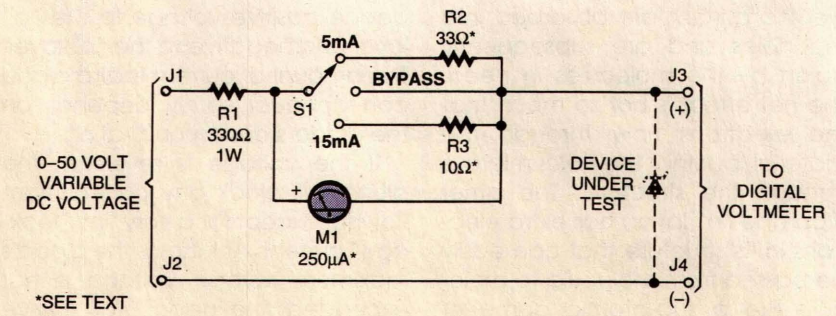


Fig. 2. For testing Zener diodes with a DC-voltage source, this circuit will deliver a controlled current to the device being tested. A voltmeter can be used to measure the Zener voltage.

Figure 1B shows the characteristics of a Zener diode, with the *cathode* connected to the positive voltage—the usual case with a Zener diode. You can see the avalanche portion, also called the Zener "knee" voltage from the shape of the plot line. To keep them straight, a Zener avalanche is called a "controlled avalanche." As long as you don't exceed the Zener's current rating, that controlled avalanche condition can be maintained without destroying the junction, essentially maintaining the Zener voltage level at the cathode.

Zener diodes are available for a wide range of voltages and power ratings. Voltage ratings are typically from 3.3 to 56 volts, and power ratings from 400 milliwatts to 5 watts. Typical prices vary depending on the manufacturer. If we take the Mouser Electronics catalog as an example, the cost would be $.18 for a 400-milliwatt Zener and $.52 for the 5-watt size in single-unit quantities—not bad for a precision-regulated voltage source.

That last statement touches on the most common uses for Zener diodes: Voltage references and voltage regulators. Zener diodes excel in those applications because they have a relatively constant voltage drop across their breakdown region, although that varies somewhat with the current passing through the diode. A Zener diode can also be used as a signal-amplitude clipper or as a direct-coupling

PARTS LIST FOR THE DC-BASED ZENER-DIODE TESTER (FIG. 2)

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted.)

R1—330-ohm, 1-watt

R2—33-ohm (see text)

R3—10-ohm (see text)

ADDITIONAL PARTS AND MATERIALS

J1–J4—Binding posts, panel-mount

M1—250-μA DC microammeter (see text)

S1—Single-pole, three-position switch

Case, wire, hardware, etc.

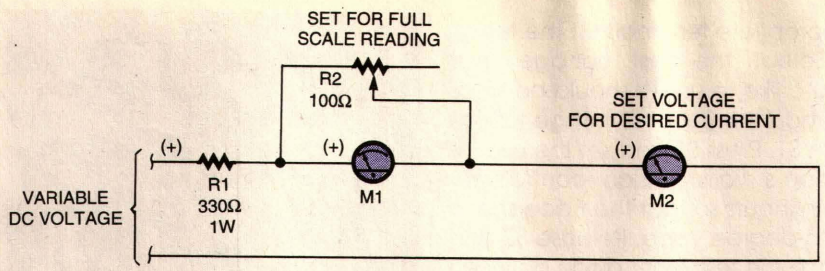


Fig. 3. For the circuit in Fig. 2 to function correctly, the values of R2 and R3 must be matched to the meter. This circuit lets you find the value of those shunt resistors.

element between amplifiers or other stages.

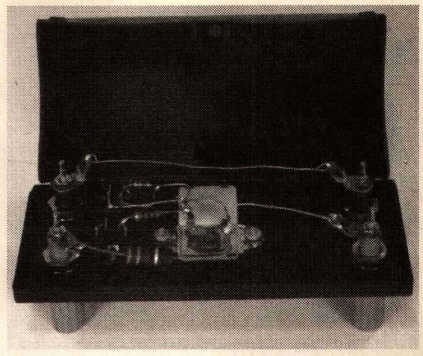
Testing Zener Diodes. Low-wattage Zeners are very small; markings are often hard to read. To make matters worse, "bargain bags" of mixed-value Zeners sold in groups at low prices might have no markings at all! In addition, some units are marked with manufacturers' codes (called "house numbers") that can be difficult to trace to a value.

Since the specified "breakdown voltage" of a Zener diode is for a particular current flow through the diode, the ideal test device should be able to establish the current flow and then measure the breakdown voltage.

While the two Zener testers described here make no claim to accurate testing of all Zener diodes under all conditions, they are certainly adequate for their purpose: Testing most common Zener diodes for their Zener voltage at typical current flows.

A DC Zener Tester. The schematic of a simple *DC-Based Zener-Diode Tester* is shown in Fig. 2. Switch S1 either selects the proper shunt across M1 for a full-scale reading at 5 mA or 15 mA, or bypasses the meter to allow greater test current.

Resistor R1 is for current limiting; the minimum safe size for power dissipation is a one-watt unit. The values of meter-shunt resistors R2 and R3 depend on the meter being



Built on the lid of a Fuji Slide Box, the DC-Based Zener Diode Tester has a built-in meter to set test current. The few parts fit nicely onto the lid.

used. To determine those values, use the circuit shown in Fig. 3. From the Fig. 1 circuit, we'll use R1 and M1. In addition, microammeter M2 is placed in series with the circuit. Potentiometer R2 is wired across M1 and initially set to zero ohms to bypass M1. Bring up the voltage so that M2 reads the desired test current. Adjust R2 for a full-scale reading on M1. The resistance of R2 is the shunt value needed for that current level with M1. Obviously, you'll have to do that test twice: At 5 mA for R2's value and at 15 mA for R3.

To use the DC Zener Tester, connect a variable DC voltage that's set close to zero volts to J1 and J2, observing the proper polarity. Set S1 to the desired test current. With a digital voltmeter connected to J3 and J4, place the Zener that you want to test across J3 and J4, making certain that the *cathode* is connected to J3 (the positive terminal).

Slowly increase the input voltage until M1 reads full scale, indicating that you've reached the selected test current. The digital voltmeter now shows the Zener voltage.

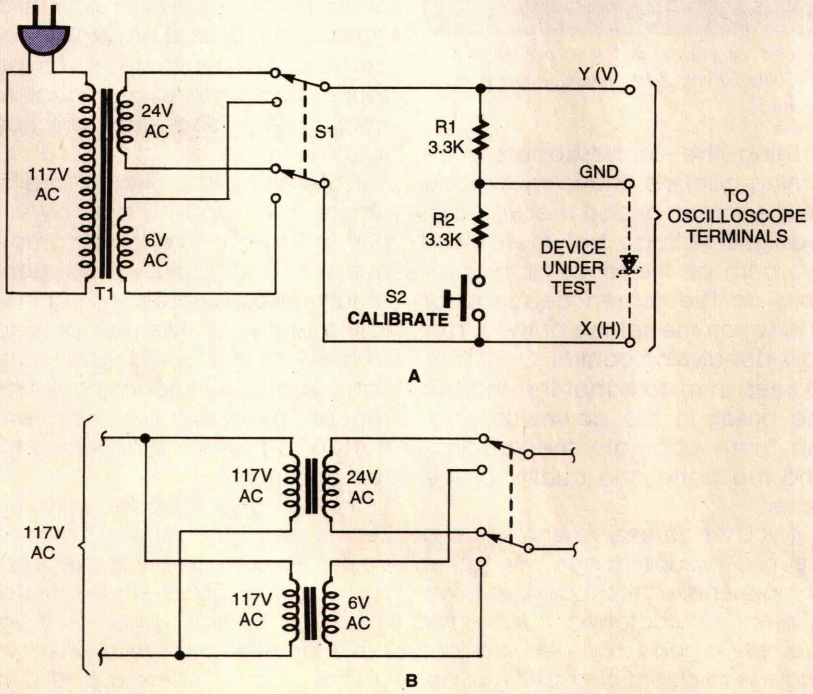
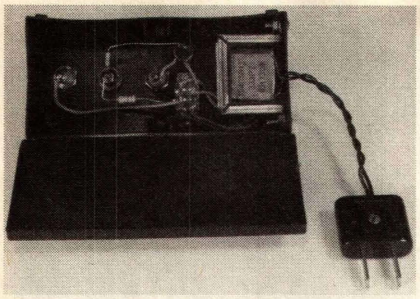


Fig. 4. If you have access to an oscilloscope, the AC-Based Zener-Diode Tester shown in (A) will let you take accurate measurements of the Zener's quality. Depending on the rating of the Zener under test, you can select one of two voltage levels. If you can't find the dual-winding transformer, you can substitute two transformers wired as in (B).

PARTS LIST FOR THE AC-BASED ZENER-DIODE TESTER (FIG. 4)

R1, R2—3300-ohm, 1/4-watt, 5% resistor
S1—Double-pole, double-throw switch
S2—Single-pole, single-throw, normally-open, momentary-contact switch
T1—6-volt/24-volt dual-winding transformer (see text)
Case, wire, hardware, etc.



The AC-Based Zener Diode Tester plugs into an AC line. It uses only two resistors, two switches, and a small dual-winding transformer mounted inside a Fuji Slide Box.

For test currents over 15 mA, use a microammeter in series between the positive voltage source and J1, and set switch S1 to bypass.

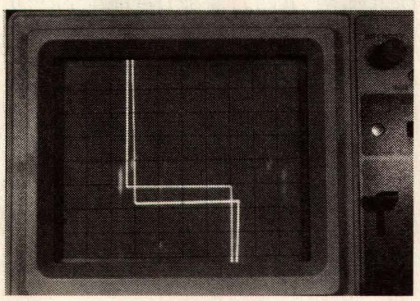
Testing Zeners with an Oscilloscope. While the Fig. 2 circuit is good for "quick and dirty" go/no-go tests, far greater information on a Zener's characteristics can be gathered by dynamically testing it with an oscilloscope. The *AC-Based Zener-Diode Tester*, shown in Fig. 4A, is our second device. Essentially a curve-tracing circuit, it uses two AC voltages and a double-pole, double-throw switch to select the test voltage. Switch S1 selects the test AC voltage, R1 is for current limiting, and R2 and S2 are used for calibration. Transformer T1 is a rather unusual unit with dual secondaries. If you can't find such a device, you can use the substitute circuit shown in Fig. 4B.

In curve tracing, a dual-trace oscilloscope is used in its "X-Y" mode. In that mode, one input moves the beam left and right (X) and the other input moves it up and down (Y). Note in the Fig. 4 schematic how the sinewave output from T1 drives both oscilloscope inputs. One connection is used as a reference, while the other receives a modified signal depending on the type of component being tested.

In order to use the curve-tracing tester, the oscilloscope and probes must be set up just right—a tricky procedure. Set the oscilloscope for X-Y input. Note that some oscilloscopes use "H" for "X" and "V" for "Y". Connect the ground connections of both probes to the ground terminal on the tester. The probes from the X and Y inputs go to the appropriate terminals on the tester.

Select the test voltage that you'd like to use (it should be higher than the Zener's voltage rating) with S1. Press S2 and set the oscilloscope's volts/division controls for both inputs so that the trace shows a 45-degree slope. Release S2 and place the test Zener diode between the ground terminal and the X input, making sure that the cathode of the Zener is connected to the X terminal.

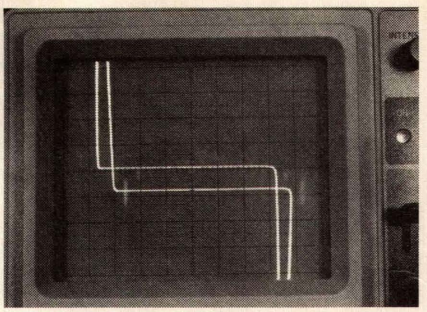
The trace should look something like the oscilloscope photos. The dual-image is due to hysteresis; don't worry about it. Just look at the horizontal lines. Between them, you should see four "corners" where the traces turn vertically. We're interested in the two trace bends in the center of the screen. Note that those two corners, while on different traces, are the two that are closest to each other.



With screen grid set at 5 volts per major division, this 20-volt Zener reads almost right on the mark.

Using the oscilloscope's positioning controls, move the image on the screen grid so that you can read the voltage between those two corners. The range of the divisions on the screen depends, of course, on the setting of the X-axis volts-per-division control. One thing to keep in mind is that the sharper the break in the downward leg, the more accurate the reading, and the better the quality of the Zener.

If you like to experiment, try using the oscilloscope tester with other components; different devices have different characteristic curves. For example, a good diode shows a right angle. A resistor of about 100K or less causes the horizontal trace to slope—the lower the resistance, the greater the slope; it will be vertical at zero ohms (continuity). With proper settings for the horizontal and vertical sensitivity, you'll find that most capacitors, transformers, DC motors, and inductors show an ellipse. Various semiconductors—transistors, bridges, regulators, and integrated circuits—show distinctive traces between pins.



With screen grid set at 1-volt-per-major-division, this 6-volt Zener reads about 6.3 volts, within the typical 10% tolerance. Note the slightly rounded knees.

Construction. No particular caution is necessary in building the testers other than to be sure that the binding posts are insulated from ground and that the AC input of the AC Tester is not exposed.

As you can see from the photographs, both units were assembled into Fuji slide boxes. Those boxes are made from thin plastic and are normally provided by photo finishers as a container for 36 slides. Other brands are similar, and are usually available at photo shops. Such boxes are ideal for small projects since they are easy to drill and cut.

Note that the circuits are so simple, they can be built by simply wiring the various components to the jacks. It's a good idea to use insulated wire or insulating tubing on the resistor leads to prevent any accidental shorts. You'll probably spend more time mounting jacks, switches, and meters to the box than wiring the rest of the circuit.

If you only occasionally use Zeners and buy them with known values—new, properly marked, and likely to be good—these testers might be overkill. However, if you have a "junk box" with unknown diodes or buy Zeners in packs—or just like to experiment—then either or both of these Zener testers are worth having; they're inexpensive, easy to make, and fun to use. P

Q&A

READERS' QUESTIONS, EDITORS' ANSWERS
CONDUCTED BY MICHAEL A. COVINGTON, N4TMI

NEED 16 VOLTS, 900 mA

Q *Recently, the power supply on my computer scanner quit working; the transformer was shot. I decided to build my own power supply with an LM317T regulator. It worked for a few days, but the voltage started dropping whenever I turned the scanner on (thermal shutdown?). My questions are: Should I use a regulated or unregulated supply? Does the tab on the LM317T have to be attached to ground or is it just for the heat sink? Could you show me a schematic that might solve my problem?—T. R. B., Sault Ste. Marie, Canada*

A Whether you need a regulated supply depends on whether the original supply was regulated. If it was just a cheap "wall wart" type of transformer, you might try RadioShack's 13.5-volt, 1-amp wall transformer; that could well be close enough to 16 volts to run the scanner properly. You won't hurt it by trying a slightly inadequate voltage for a short time.

It sounds like you already have a working circuit that needs only minor changes. The tab on the LM317T is connected internally to the output (not ground!) and should be isolated from ground.

Your problem does indeed sound like thermal shutdown. The LM317T automatically shuts down when it gets too hot. A bigger heat sink is in order; be sure to use heatsink grease and a mica insulator to couple the LM317T to the metal.

How high is the voltage going into the LM317T? I ask that because the LM317T cannot dissipate more than 15 watts, regardless of current. Recall that

$$\text{watts} = \text{volts} \times \text{amps}$$

The voltage that matters is the drop taking place within the regulator. For example, if your load is drawing 0.9 amps (900 mA) and the LM317T has 40 volts coming in, it's trying to dissipate $(40 - 16) \times 0.9 = 21.6$ watts. That's too much; it will go into thermal shutdown.

Assuming that you can't change to a lower-voltage transformer, one way to reduce the input voltage is to run it through a string of 1N4001 diodes—each of which will take off about 0.7 or 0.8 volt. Another way is to use two regulators in cascade. For example, if you're starting with 30 volts, use one LM317T to get it down to about 23 volts and feed that into another 317T to take it down to 16 volts. That way, each LM317T does only half as much work and gets only half as hot. Not only that, but you should get really good regulation.

See RadioShack's book *Building Power Supplies* for more advice.

MIDI MATERIAL

Q *I am a practicing musician and electronics buff and would like to learn more about MIDI (Musical Instrument Digital Interface). Where can I get full specifications?—E. J., Tuczon, AZ*

A MIDI is both a file format and an electronic interface for representing music as musical notes rather than just recording sound waves. Like a band director, you can alter the way a computer "performs" a MIDI file, edit the musical score, and replace one instrument with another.

One of the best technical introductions to MIDI that I've seen is Application Note AN027, "A Tutorial on MIDI and Wavetable Music Synthesis," by Jim Heckroth. It is published by Crystal Semiconductor, which is now a part of Cirrus Logic. To find it, go to *www.crystal.com* and do a search for "MIDI" or write to the company at 3100 West Warren Ave., Fremont, CA 94538. In the past, this application note was included in their audio databook; maybe it still is.

Go to *www.amazon.com* or *www.bn.com*, and you'll find dozens of books about MIDI (as well as a book about dog care by someone named Midi Fairgrieve—aren't search engines marvelous?). Most of these books are relatively nontechnical, but some particularly stand out. They are *Advanced MIDI User's Guide* by R. A. Penfold, a slim volume by a well-known electronics writer; *Maximum MIDI: Music Applications in C++* by Paul Messick (450 pages plus CD-ROM); and, above all, *Midi for the Professional* by Paul Lehrman and Tim Tully, used as a college textbook.

BROKEN WINDOWS

Q *My AMD 300-MHz Windows 98 computer has been giving me occasional page faults and general protection faults, about once a week. When the fault window comes up, I click on "Details" and get hex addresses and data. Numerous books on troubleshooting PCs haven't helped me decipher those messages. Can you?—L. R., Huntington Beach, CA*

A Unless you're one of the authors of Windows with access to the source code, those dumps of the contents of memory aren't going to tell you anything. However, some things that you can check include:

- Try to pin down the conditions under which the messages occur. Page faults and general protection faults mean that a program is trying to use a nonexistent memory location. Does this happen when you use a specific piece of software? If so, that software is probably corrupted and needs to be reinstalled and/or updated. If the failures are random, the culprit is the operating system or the hardware.
- If the message mentions a specific file (such as USER32.DLL) or contains other distinctive text, go to *support.microsoft.com* and try to look it up. Sometimes Microsoft has a ready-to-use solution.
- Run the "System File Checker" utility to see if any part of Windows 98 has been corrupted. From the "START" button, choose "RUN..." and type SFC.EXE in the box.
- Look for DLL conflicts. From the "START" button, use "FIND" to locate all files on the system with names ending in .DLL (dynamic-link libraries). If you find several with the same name that are not copies of the same file, copy the newest one into the \WINDOWS\SYSTEM folder. Rename all of the others (by changing ".dll" to ".dll.old") so

HOW TO GET INFORMATION ABOUT ELECTRONICS

On the Internet: See our Web site at *www.gernsback.com/poptronics* for information and files relating to **Poptronics** and our former magazines (**Electronics Now** and **Popular Electronics**) and links to other useful sites.

To discuss electronics with your fellow enthusiasts, visit the newsgroups sci.electronics.repair, sci.electronics.components, sci.electronics.design, and rec.radio.amateur.homebrew. "For sale" messages are permitted only in rec.radio.swap and misc.industry.electronics.marketplace.

Many electronic component manufacturers have Web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www. motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online: www.questlink.com features IC data sheets and gives you the ability to buy many of the ICs in small quantities using a credit card. You can also get detailed IC information from www.icmaster.com, which is now free of charge although it formerly required a subscription. Extensive information about how to repair consumer electronic devices and computers can be found at *www.repairfaq.org*

Books: Several good introductory electronics books are available at RadioShack, including one on building power supplies.

An excellent general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is *The ARRL Handbook for Radio Amateurs*, comprising over 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham-radio equipment dealers.

Copies of past articles: Copies of past articles in **Electronics Now, Popular Electronics** (post 1995 only) and **Poptronics** are available from our Claggk, Inc., Reprint Department, P.O Box 12162, Hauppauge, NY 11788; Tel: 631-293-3751.

Electronics Now and many other magazines are indexed in the *Reader's Guide to Periodical Literature,* available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

Service manuals: Manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214; (800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, PO Box 549, Tooele, UT 84074.

Replacement semiconductors: Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including RadioShack on special order). The ECG, NTE, and SK lines contain a few hundred parts that substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use. NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations: These can be located by writing to the American Radio Relay League, Newington, CT 06111; (http://www.arrl.org). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts—both amateur and professional.

that they will not be used. The file "msvcrt40.dll" is a frequent offender.

- Look for hardware problems. Your problems might indicate that a memory module is loose in its socket, a power-supply voltage is marginal, or a chip (perhaps the CPU) is running too hot. Try unplugging all of the internal connectors (using anti-static precautions, of course) and plugging them back in.
- Test memory with a test package such as AMI Diagnostics (which can be purchased from *www.ami.com*). Run the memory checks repeatedly; they are more sensitive than the tests performed by your BIOS.

A "haunted" Windows system like this can be a real annoyance. Today's computers are perhaps a billion times as complicated as yesterday's radios and TVs; if they weren't able to test themselves, they'd never work at all!

ONE TERMINAL, THREE COMPUTERS

Q *With the increasing popularity of Linux, I find myself having three computers networked in my home. Since monitors, keyboards, and mice take up space, I would like to use just one monitor, keyboard, and mouse and switch them between the three computers. I know there are commercial units available to do this, but they are too expensive for me. Any ideas?—M. P., L'Assomption, Quebec, Canada*

A The fact that you've chosen Linux makes it easy: use one of the computers as a terminal on the other two. Linux is a multi-user operating system designed for access from remote terminals, which can be attached to serial ports or a local-area network.

You can use the "telnet" command to use any Linux or Windows system as a terminal to another Linux system. If you need graphics, use one Linux system as an X-Windows System terminal accessing the others.

You will need to set "keyboard not installed" in the BIOS of each PC that does not have a keyboard, so that you don't get that memorable error message, "Keyboard not found. Press any key to continue!"

WAITING FOR CALL WAITING

Q *I have Call Waiting, and when I'm on the Internet, I can't hear the beeps that indicate that a call is coming in, so people think I'm not at home. Can you design a circuit that can recognize these beeps and flash a light or sound a buzzer?—F. G., Bogota, Colombia*

A Until recently, modem users had a much worse problem—their modems would hear the beeps and simply disconnect them from the Internet. Nowadays, many modems will ignore the beeps.

You could tap your telephone line and feed the audio through a narrow-band filter and into an audio amplifier. Not knowing the frequencies used for Call Waiting beeps in Colombia, I'm not quite ready to design this. Also, the narrow-band filter would probably pass along a lot of the wideband signal from the modem, as well as the beeps. You might need to use a phase-locked loop such as the NE567 tone decoder.

If it worked, this circuit would immediately raise another problem: when you hear the signal, what will you do? Disconnect from the Internet instantly, losing whatev-

(Continued on page 54)

SAM GOLDWASSER

Common VCR Problems

Now that we have completed the basics, we can finally begin to tackle actual VCR failures. First, we will look at those that deal with getting the cassette into position or removing it, and then check out fundamental fast-forward and rewind issues. All of these problems are usually caused by mechanical or sensor-related faults.

Cassette-Loading and Eject Problems

Cassette loading places the cassette into proper position on the tape transport. In a front-loading VCR, pushing the cassette gently into the slot should cause a motor to take over and suck it in and down to rest on indexing pins. The mechanism that actually holds the cassette is called the cassette basket. Several problems are possible. They usually fit into the following two categories:

1. The VCR may ignore you when you push the cassette in or press EJECT.
2. The VCR may immediately spit out the cassestte or it may cycle back and forth.

On a top-loading VCR, you do most of the cassette loading manually, so the only likely problem is that EJECT does not work.

If attempting to load a cassette produces no response (assuming that the VCR has power), then there could be a problem with the microswitch that senses the presence of a cassette or with the cassette-loading motor (if the particular VCR has a separate cassette-loading motor), a slipping or broken belt, or a faulty driver or other electronic difficulty. Sometimes this could mean that the microcontroller is confused because of a faulty mode switch or because the mechanism somehow got into a peculiar state.

Manual cycling of the cassette-loading mechanism might reset it. So the first thing you should try—with the VCR unplugged—is to gently push a cassette in and turn the appropriate shaft or pulley by hand. If nothing happens or you feel resistance, try the other direction. Assuming you find no problems—there is no significant resistance to turning the mechanism, and the cassette basket cycles from fully ejected to fully seated on the transport base plate—leave the cassette basket in a partially loaded position. Then plug the VCR into the AC power, and turn it on (this may not be necessary depending on the design of your VCR). It should now reset itself and either load or eject the cassette. If there are still no signs of a response, a power supply, motor, or electronic problem is likely.

Note that if this only happens with T160 (8 hour) tapes, the thinner tape may be confusing the sensors. Avoiding these tapes is really the best thing to do since they can cause all sorts of problems (especially if they are an off-brand and of inferior quality to begin with).

If you hear a motor whirring but nothing happens, this is almost certainly a slipping or broken belt or something blocking the proper movement of some mechanical part.

If pushing a cassette into the VCR results in it being ejected as though it tasted really bad (there may or may not be hesitation), or if the cassette cycles back and forth without stopping, there are several possible causes to consider.

If it stops partway during loading, does it pause as though the motor is straining or does it just abort with no warning? If the former, then check carefully for foreign objects or lack of lubrication. A typical cause is a belt slipping, usually not the idler in this case. Help it out gently and see if that will complete the cycle. Sometimes it is helpful to cycle the mechanism by hand—turn the appropriate shaft or pulley and feel and watch for any place where it binds. If the basket moves in the wrong way or you feel any significant resistance, try the other direction. Sometimes, the sticky cassette labels partially or totally peel off and clog the works. You might find a toy or rock inside carefully inserted by some 3 year-old! A bit of the cassette shell might have broken off and jammed the mechanism just to confuse you!

If the microcontroller were detecting an abnormality, tape loading would abort instantly, but would most likely try to unload the tape before giving up. This is true of many, but not all designs. It is possible that an abort could be initiated if the end-of-tape or beginning-of-tape sensors are not working properly. In some cases, the mode switch may be dirty or faulty. A gear may have some broken teeth or may have slipped a couple of teeth and the timing relationships may be incorrect. There might be a microswitch that is controlled by the cassette basket position, and it might be defective or dirty.

Similarly, if the cassette seems to be cycling in and out in an apparently infinite loop, there may be an obstruction, or the microcontroller may be confused by a bad sensor, or the basket is out of synchronization with the rest of the mechanism. A squirt of contact cleaner into the microswitch sensor and/or reflowing its solder connections may solve this type of problem.

Similar comments apply to cases where pressing the EJECT button produces no response. In particular, if the cassette was loaded successfully and you just finished a thoroughly enjoyable movie, the microcontroller may think the mechanism is not safe and is not ejecting to protect your valuable tape

from possible damage should it not be fully retracted into the cassette. As with loading, EJECT may result in partial movement and shutdown or reloading the cassette into the down position. All the same causes apply.

There are even some poorly designed VCRs where extraneous light through the vent holes or tape door affect sensors and cause erratic operation. If a bright light is shining on the VCR, block it and see if anything changes!

Ejecting a Cassette From an Uncooperative VCR

Have you had this common experience—the rental movie is due back at the video store *now* but no matter how you press the EJECT button, yell, scream, hold your breath, or jump up and down, the cassette refuses to reappear. To remedy the underlying problem, see the information above. This section only deals with getting the cassette out without damaging either your valuable recording or your VCR. Under no circumstances should you force anything. If you do, both your tape and your VCR could be seriously damaged.

To begin, see if the VCR just got itself confused. Pull the plug and patiently wait a minute or two. This may reset the microcontroller and all will be well. These things happen. If this is not successful, you will need to open the VCR (unplug it first!) and attempt to cycle the mechanisms by hand. You will probably have to remove both the top and the bottom covers. The following procedures assume that there are no broken parts, foreign objects, or other damage, which might prevent manual cycling of the tape-loading and cassette-loading mechanism. (Inspect for toys and rocks.) Also, note that some VCR designs use solenoids to start various operations. This will complicate your task (to put it mildly) as locating and activating the proper ones at the appropriate time is, well, a treat.

Tape unloading: The first step is to determine if the tape has been unloaded from the video head drum back into the cassette. If the tape is fully retracted into the cassette—there is no tape showing, then check out the next section. If not, you will need to figure out which shaft or pulley to turn to unload the tape. Trace the linkage or gears that move the roller guides back to their motor—it may be the main capstan motor or a separate small motor used only for this purpose. Rotate this in the direction that moves the roller guides back towards the cassette. It will take many revolutions—be persistent. If you feel any significant resistance or the roller guides move out toward the drum, turn the other way. The tape is fully unloaded when the roller guides are all the way into the cassette and the tape is straight across the cassette's stationary guideposts. If a single motor performs both the tape-loading and cassette-loading functions, stop turning as soon as you see the cassette start to rise. Read the next section before proceeding.

If you are not successful or if there is still a tape loop outside the cassette even after you have rewound the tape for what seems to be an eternity, you can still try to eject the cassette but will need to be extra careful not to crinkle the tape as the cassette door closes with the tape sticking out. Before doing this, try to find a way to turn one of the reels to pull that tape back in, as this will make your task a lot easier. There may be an idler that swings between the two reels and this may be accessible from the bottom (the cassette will block it on top).

Cassette unloading: Once the tape is fully retracted into the cassette, the cassette can be ejected safely. If a tape loop is still sticking out of the cassette and you care about the recording, you will need to be especially careful not to crinkle the tape as the cassette door closes. It is usually not possible to get the cassette fully out without the door closing, so the best you can do is to make sure that the tape is flat across the gap. With care, it should survive. On a top loader, there is usually a solenoid specifically for eject or a simple mechanical pushbutton. Once the appropriate lever is pressed, the cassette should pop up. Hold the basket with one hand as you do this to prevent any exposed tape loop from being crinkled.

On a front loader, locate the cassette-loading motor and begin turning it in the appropriate direction. This will be fairly obvious assuming that there are no broken gear teeth or other broken parts and that something isn't totally jammed. If this is the main capstan motor, then just continue turning as I mentioned above. Eventually the cassette should rise up and out. If you have an exposed tape loop, be extra careful not to catch it on any guideposts or other obstructions as you remove the cassette. Then, wind it back into the cassette by turning one of the reels (you may have to depress the release button on the bottom of the cassette with a pencil. This is the small hole in the center near the label side.) Assuming the tape is not torn and not badly crinkled, it should be fine. If it is severely damaged, throw it away since such a tape can ruin the video heads in your VCR. If you must recover what's on it, it may be possible to just copy the portions before and after the damage by installing them in separate cassettes.

VCR is Confused—The Lights Are On, But Nobody's Home

If the microcontroller refuses to raise the basket although there is no tape present, try pulling the plug for a minute or two. This may reset the error condition. However, since the mechanism is in an illegal state, the microcontroller may refuse to do anything for fear of making things worse. If the problem is still there, here are two suggestions:

Manually turn the appropriate motor shaft with power off to put the mechanism through the eject cycle. In many VCRs, this is as simple as turning the eject motor or possibly the main motor. Be patient and gentle—it will take a while. If there is some underlying problem which caused the basket to be lowered without a cassette in place, then the VCR may return to the illegal state, do nothing, or do something else peculiar once power is restored or any button is pressed.

Convince the microcontroller that a tape really is present when there is none. To do this, you need to first cover the start/end sensor LED poking up in the center of the deck. Then you depress any other microswitches that sense tape present and press the EJECT button. You may also need to turn the non-driven reel by hand a bit while it is attempting to wind the tape loop back into the cassette. Sometime you have to do all of these things at the same time. Three or four hands are a definite asset. Make sure you get your fingers out before they are caught! Again, an underlying problem may produce unexpected results.

Going Nowhere Fast—No Fast Forward Or Rewind

Usually, the owner will admit that the machine is pre-Jurassic and has never been cleaned or serviced. Your first step is to rule out the idler tire as

(Continued on page 57)

GORDON MCCOMB

A Different Type of Tilt Sensor

Every school child learns that the human body has five senses: sight, hearing, touch, smell, and taste. However, another important "sense" is the sense of balance. This sense is made possible by a complex fusion of nerves throughout the body, including those in the inner ear. Balance helps us to stand upright and to sense when we're falling. Our sense of balance combines information about both the body's angle and motion. At least part of the sense of balance is derived from a sensation of gravity—the pull on our bodies from the earth's mass.

Consider the possibilities if a robot were given the ability to "feel" gravity. The same forces of gravity that help us to stay upright might provide a sensation to keep a two-legged robot upright. On the other hand, a rolling robot—on wheels or tracks—might avoid tipping over and damage by determining if its angle is too steep. The robot might avoid traveling over that terrain, or it might shift some internal ballast weight (assuming it were so equipped) to change its center of balance.

In this column, I will be discussing the use of relatively inexpensive accelerometers as a robotic tilt sensor. With a microcontroller such as the Basic Stamp or NetMedia BasicX-24, the output of the accelerometer can be readily converted into "balance" data for a robot.

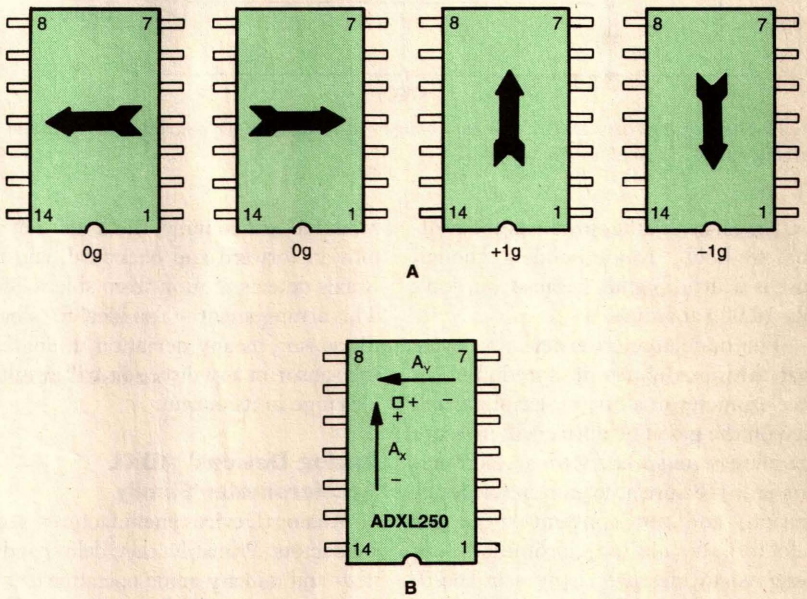


Fig. 1. Either single-axis accelerometers (A) or dual-axis accelerometers (B) can be used to measure the tilt of a robot.

Sensors for Tilt Measurement

One common way to provide a robot with a sense of balance is to use a tilt sensor or tilt switch. The sensor or switch measures the relative angle of the robot with respect to the center of the earth. If the robot tips over, the angle of the sensor/switch changes; this can be detected by electronic circuitry in the robot. Tilt sensors and switches come in various forms and packages.

Common varieties include the following:

Mercury-filled glass ampoules that form a simple on/off switch. When the tilt switch is in one position (say, horizontal), the mercury touches two or more contacts inside the ampoule, closing the switch.

Ball-in-cage. These all-mechanical switches are popular in pinball machines and other devices where small changes in level are required. The weight of a ball inside the switch completes an electrical circuit. The capsule may have multiple contacts to make it possible to measure tilt in many directions.

Electronic spirit level sensors use the common fluid bubble, along with some interfacing electronics. Titling the tube makes the bubble slosh back and forth, because of gravity. An optical sensor—an infrared LED and detector, for example—can be used to measure the relative size and position of the bubble.

Electrolytic tilt sensors are like mercury switches, but are more complex, and a lot more costly. In an electrolytic tilt sensor a glass ampoule is filled with a special electrolyte liquid—a liquid that conducts electricity, but in very measured amounts. When the switch tilts, the conductivity between two (or more) metal contacts changes.

One of the more accurate, yet surprisingly low-cost, methods of measuring tilt is with an accelerometer. Once used only in the realm of high-tech aviation and automotive testing labs, accelerometers are quickly becoming common staples in consumer electronics. It's quite possible, for example, that your late-model car contains at least one accelerometer—if not a part of its collision safety system (such as an airbag), then perhaps an integral part of its burglar alarm. Accelerometers are also increasingly used in high-end video game controllers, portable electric heaters, and in-home medical equipment.

New techniques in manufacturing accelerometers have made them more sensitive and accurate, yet less expensive. A device that might have cost upwards of $500 a few years ago sells today in quantity to manufacturers for under $10. Fortunately, the same devices that are

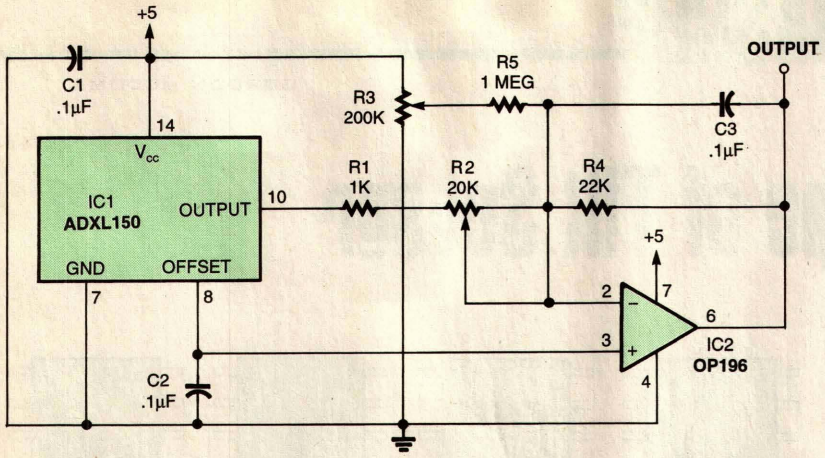


Fig. 2. The output of the ADXL is a linear voltage proportional to the amount of acceleration. An op-amp scales and amplifies the voltage.

used in cars and other products are available to hobby robot builders, though cost is a little higher because we don't buy 10,000 at a time!

The basic accelerometer is a device that measures *change* in speed. Put an accelerometer in a car, for example, and step on the gas. The device will measure the increase in speed. Most accelerometers only measure acceleration (or deceleration) and not constant speed (or velocity). While accelerometers are designed to measure changes in speed, many types are also sensitive to the constant pull of the earth's gravity. It is this latter capability that interests us, as we want to use the accelerometer to measure the tilt, or "attitude," of the robot at any given time. This tilt is represented by a change in the gravitational forces acting on the sensor. The output of the accelerometer is either a linear AC or DC voltage, or, more handily, a digital pulse that changes in response to the acceleration or gravity forces.

The basic accelerometer is single axis; it can detect a change in acceleration (or gravity) in one axis only, as shown in Fig. 1A. While moderately restrictive, you can still use such a device to create a capable and accurate tilt and motion sensor for your robot. The first accelerometer project, described a bit further on in this month's column, uses just such a single-axis device.

A dual-axis accelerometer detects changes in acceleration and gravity in both the X and Y planes (see Fig. 1B). If the sensor is mounted vertically—so that the Y axis points straight up and down—the Y axis detects up and down changes, and the X axis detects side-to-side motion. Conversely, if the sensor is mounted horizontally, the Y axis detects motion forward and backward, and the X axis detects motion from side to side. This arrangement is also ideal for a basic tilt sensor, as any deviation in angle of the sensor in any direction will result in a change in its output.

Analog Devices' ADXL Accelerometer Family

Analog Devices manufactures semiconductors. Primarily, they deliver industrial- and military-grade operational amplifiers, digital-to-analog and analog-to-digital converters, and motion control products. One of their key product lines is accelerometers, which use a patented fabrication process to create a series of microscopic mechanical beams. In operation, each beam is distended along its length due to motion or gravity effects. This distention changes the capacitance in nearby plates. The capacitive change is correlated as acceleration or deceleration.

Although a thorough discussion of the theory of operation of the ADXL accelerometers is beyond the scope of this column, you can find much more on the subject directly from the manufacturer; check their Web site at *www.analog.com.*

In addition to the mechanical portions of the accelerometer, all the basic interface circuitry is part of the device. In fact, if you were looking at one of the ADXL accelerometers, you would think that they were just integrated circuits of some type. Because the basic circuitry is included as part of the accelerometer, only a minimum number of external parts are needed. In our first project, only eight external parts are used, three of which are filtering/bypass capacitors to reduce the effects of electrical noise. The second project uses even fewer external parts.

Constructing a Single-Axis Accelerometer Robotic Sensor

The single-axis accelerometer outlined here is based on Analog Devices' ADXL150JQC. The device combines a micro-machined mechanical accelerometer with on-board amplification electronics. The normal range of this accelerometer is ±50 *g* (a *g* is the unit of measure of gravitational pull; one *g* is equal to the gravitational pull on the surface of the earth). This range is actually too high for most robotic applications, so we will scale it down to about ±5 or 10 *g*.

The output signal of the ADXL150 is a voltage. We'll be using the ADXL-150 in full DC mode, where the output will swing no less than about 2.5 volts as the sensor detects changes in acceleration. Depending on how you adjust the sensor board, you can get the ADXL150 to deliver close to the full 0- to 5-volt output range. The broader the range of voltage, the more resolution the sensor will provide. At a scaling factor of ±5 *g*, the sensor can detect a change of 400 mV per *g*. With an 8-bit analog-to-digital converter (ADC) measuring the full 4000-mV (4-volt) range, this equates to a resolution of 15.625 mV per step, or roughly 0.06 *g*; not bad. A 10- or 12-bit ADC will provide even greater resolution.

The one "gotcha" of the ADXL150 is that it is a 14-pin surface-mount component, making it difficult to use in a homebrew circuit. Fortunately, there are a number of techniques to use for most any other surface-mount part:

- Use an IC surface-mount carrier board. Carefully solder the surface-mount component onto the carrier board. The carrier can then be used in ordinary breadboards and prototyping boards. The leads of the ADXL150 are pre-tinned, so you need only hold the part in place for the first "tack" with your soldering pencil. Repeat the process for each of the other leads. Be sure to buy a carrier board that has solder pads appropriately spaced for the ADXL150. Most IC carrier boards are made for thinner packages. The ADXL150 is in a "fat" ceramic package and is wider than most ICs.
- Solder short lengths of 30 AWG wire-wrap wire to each of the ADXL150's leads. This is delicate work, and it requires expert soldering and a good eye (it was the technique I used for my prototype).

• Design and etch your own surface-mount board, custom-made for the ADXL150.
• Purchase the ADXL150 Evaluation Board, available directly from Analog Devices and several online and catalog merchants, such as Allied Electronics (*www.alliedelec.com*). This is perhaps the easiest method.

Figure 2 is a schematic that shows the ADXL150 set up as a general-purpose accelerometer, suitable for measuring tilt, vibration, and, of course, acceleration. This circuit was adapted from the data sheet provided for the ADXL-150, with parts values suitable for our robotic endeavors.

The heart of the circuit is the ADXL150, which is powered by 5 volts DC. Capacitors C1, C2, and C3 are for power-supply bypass and are included to reduce noise on the output. IC2 is an Analog Devices OP196 rail-to-rail operational amplifier. This is the op-amp called for in the data sheet for the accelerometer, and for good reason. It not only offers good gain with low noise, but it is designed to accept a single-ended supply—that is +5 volts and ground. Though the OP196 op-amp is called for, most any single-ended rail-to-rail op-amp will probably work, but your results may vary. The LM741 op-amp is specifically *not* recommended.

Listing 1

```
' ADXL150 test program
' For use with BasicX-24 microcontroller
' Output of ADXL150 is connected to pin 13 (IO line 7)
'  of the BasicX-24

Dim Voltage As Integer, BlinkTotal As Integer
Dim Total As Long
Const PinNumber As Byte = 13
Const GreenLED As Byte = 26
Const RedLED As Byte = 25
Const LEDon As Byte = 0
Const LEDoff As Byte = 1

Sub Main()
   Dim x as Byte
   Total = 0
   Do
         For x = 1 to 254                ' adjust for "filter"
               Voltage = GetADC (PinNumber)
               Total = Total + CLng(Voltage)
         Next
         Total = Total \ 254             ' adjust for "filter"
         BlinkTotal = CInt(Total)
         Call LEDs
         Call Delay(0.1)
   Loop
End Sub

Sub LEDs()
   If BlinkTotal > 825 Then              ' adjust as needed
         Call PutPin(RedLED, LEDoff)
         Call PutPin(GreenLED, LEDon)
   Else
         Call PutPin(GreenLED, LEDoff)
         Call PutPin(RedLED, LEDon)
   End If
End Sub
```

How the Circuit Works

Resistors R1 and R2 provide the scale factor. The values chosen reduce the scale factor to between about ±5 and 10 *g*. According to the datasheet for the ADXL150, total resistance for R1 and R2 should be from 10K to 20K. I have specified a 1K resistor, and a 20K potentiometer. If you want to read higher *g* ratings—you intend to launch your robot in a rocket, for example—increase the value of R1 and R2.

Potentiometer R3 serves as a 0-*g* scale adjust, which may or may not be critical for your application. On first use, center the pot, and adjust it so the ADXL150 outputs a voltage in the middle of the scale when the sensor is turned on its side. With the sensor pointing arrow-up, the reading will be for +1 *g*; with the sensor pointing arrow-down, the reading will be for –1 *g*.

Resistor R4 sets the gain of the op-amp and should be selected to match the input provided by R1 and R2. I'll let you read the datasheet for the details, but for the prototype I used a 22K resistor. Finally, C3 serves to set the low-pass filtering from about 8 to 10 Hz. With a lower value (0.01 or 0.001 µF, for instance), you increase the bandwidth, but add noise to the output. A higher value (e.g. 1 or 2 µF) will decrease bandwidth and noise. However, very high capacitances make the output of the ADXL150 sluggish.

I mounted the ADXL150 to a 14-pin wire-wrap socket using double-sided foam tape. I had previously soldered wire-wrap wire to each pin of the ADXL150; the free end of each wire was then attached to the pins of the socket. After inserting the socket into the prototyping board and soldering it in place, I clipped off the excess length of the socket pins. Note that in my prototype, I soldered a wire to *every* pin on the ADXL150, but this is not needed. Only pins 7, 8, 10, and 14 need to be connected to anything; pin 9 is only used for the self-test function and should not be connected.

Applications for the ADXL150

After constructing the ADXL150 sensor board, connect the power leads to a suitable 5-volt DC power supply, and connect the output to a fast-acting meter or oscilloscope. While slowly moving the sensor board in various directions, adjust R2 and R4 for maximum voltage change. You will need to experiment with different settings to achieve the output you want, based on your planned application of the ADXL150.

A level or tilt sensor. Position the ADXL150 so it points arrow-up (+1 *g* setting). Any tilt in any direction will then be registered as a negative-going voltage change. For this application, you want a low-g scale, so be sure to adjust R2 near its minimum and R4 near its maximum.

A movement sensor. Position the ADXL-150 so that it points arrow-forward (arrow to the front of the robot). For a slow robot, a rather low-*g* scale is usually desired, but adjust accordingly. Some small robots turn and spin on their axis

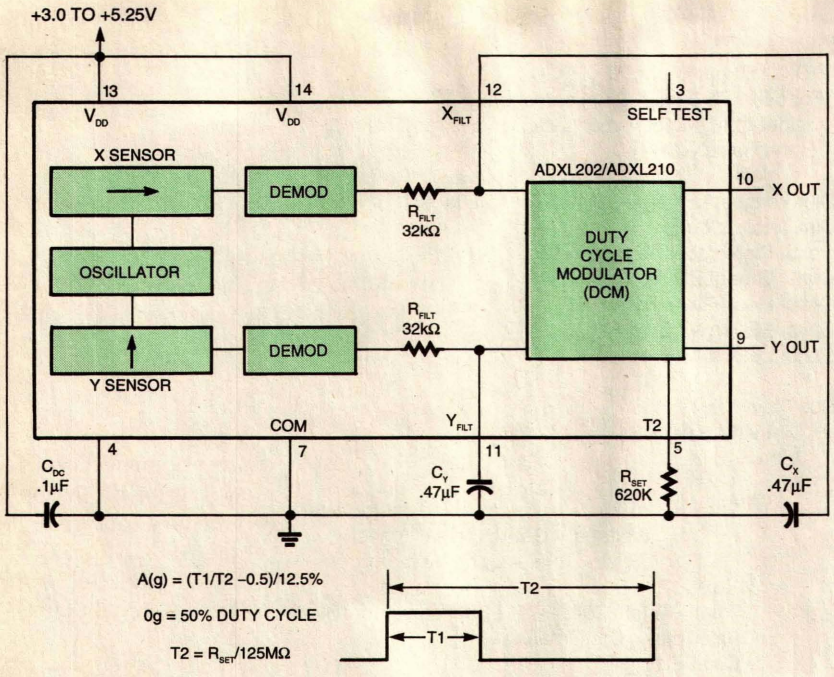


Fig. 3. The ADXL202 two-axis accelerometer is easy to use, requiring only four external parts. The output of the device is a digital pulse train.

very quickly, producing momentary forces of 2 or 3 *g*!

A shock or vibration sensor. Position the ADXL150 in horizontal or vertical position, as desired. The scale setting should be adjusted based on the sensitivity you need. If you do not want the robot to be highly sensitive to minor bumps and grinds, for instance, set a high-*g* scale by increasing R2 and decreasing R4.

Of course, to be of any use, the accelerometer should be interfaced to a computer or microcontroller via an analog-to-digital converter. The BasicX-24 microcontroller from NetMedia (*www.basicx.com*), is pin-for-pin compatible with the Basic Stamp II from Parallax, but includes an on-board analog-to-digital converter (ADC). This ADC is the "multiplexing" type, so you can use any (and all) of eight different data lines to read analog data. This feature of the BasicX-24 makes it particularly well-suited for use with sensors such as the ADXL150 accelerometer, as no external ADC circuit is required.

Listing 1 shows a test program for the BasicX-24 microcontroller and how to use the ADXL150 as a tilt sensor. The amplified output of the ADXL150 is connected to pin 13 (I/O line 7) of the BasicX-24. The main body of the code—defined by the Main() subroutine—is an endless loop that constantly collects data from the accelerometer. A "software filter" is used to average out the values of the ADXL150. I set the filter to average 254 samples of data from the accelerometer; you can select a lower value if you don't want to sample as many data points.

When running, the program changes the color of the LED built onto the BasicX-24 carrier board. With the ADXL150 pointing "up" so that the output is at its highest level, the green LED lights. As the ADXL150 is tilted horizontally, the output decreases; the red LED lights instead. You'll need to experiment with the "setpoint" (I used 825, which I found through trial and error), depending on the actual values provided by your ADXL150 circuit.

Constructing a Dual-Axis Accelerometer Robotic Sensor

The ADXL150 single-axis accelerometer that we have been working with has a close sibling: the ADXL250, which combines two accelerometers in one. The ADXL250 is a dual-axis device, with the axes oriented at right angles to one another. When the accelerometer is positioned horizontally, it can detect motion in 360 degrees (it cannot detect up and down motion when in this position, however).

Using the ADXL250 is very similar to using the ADXL150—you just duplicate the interface electronics for the second axis. Refer to the datasheet for the ADXL250 on the pinout diagram for the device.

Analog Devices makes a lower-cost line of accelerometers specifically designed for consumer products. Their ADXL202 is a dual-axis device that has a ± 2 *g* sensitivity (if you need more *g*'s, check out the ADXL210, which is rated at ± 10 *g*'s). Besides being less expensive than the ADXL150/250, the ADXL202 has a simplified output: instead of a linear voltage, the output is purely digital. As acceleration changes, the timing of the pulses at the output of the ADXL202 change; this change can be readily determined with a PC or microcontroller, using simple software. No op-amp or scaling-adjustment components are necessary.

Like the ADXL150, the ADXL202 is a surface-mount component. See the discussion in the ADXL150 section about alternatives for interfacing the ADXL202 with the electronics in your robot. By a long measure, the ready-made ADXL202 Evaluation Board is the easiest way to use this device. It comes on a small postage-stamp carrier that can be directly soldered to the BASIC Stamp or other microcontroller.

The basic hookup diagram for the ADXL202 is shown in Fig. 3. Note that

Listing 2

```
' ADXL202 test program
' For use with Parallax Basic Stamp II
' Connect as detailed in text

Freq      Var     Word
T1x       Var     Word
T1y       Var     Word
T2 Var    Word

Low       0       ' self-test, pin 0
Input     2       ' X accell, pin 2
Input     4       ' Y accell, pin 4
High      6       ' V+ pin 6

Count 4, 500, Freq
T2 = Freq * 2

Repeat_Loop:
   debug cls
   Pulsin 2,1,T1y
   T1y = 2 * T1y
   Pulsin 4,1,T1x
   T1x = 2 * T1x
   T1y = 8 * T1y / T2
   T1x = 8 * T1x / T2
   debug dec T1x, tab, dec T1y, tab, cr
   Pause 150
   Goto Repeat_Loop:
```

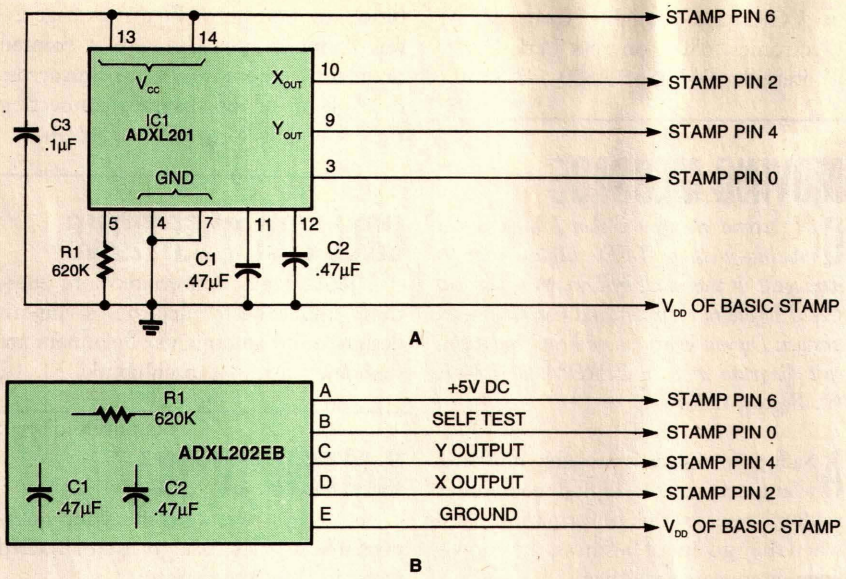


Fig. 4. Connection diagram for interfacing the ADXL202 to a Basic Stamp II. For ease of testing the Stamp's IO pin 6 provides +5 volts DC.

except for two filter capacitors and a single resistor, there are no external components. I have specified a rather low bandwidth for the device, about 10 Hz. According to the ADXL202 datasheet, the value for C1 and C2 for this bandwidth should be 0.47 µF.

Resistor R1 sets the value of the timing pulse, used for the output of the X- and Y-axes of the ADXL202 chip. I have specified a modest timing pulse of 5 milliseconds. According to the datasheet, this requires a nominal value of 625 kohms (620k is a more practical actual value and is shown in the schematic) for R1. Note that the exact timing of the pulse is not critical, as any variation will be accounted for in software. You will want to select a higher or lower timing pulse based on the capabilities of the PC or microcontroller you are using, and the resolution you desire.

The output of the ADXL202 is a steady stream of square waves. The timing of the pulses, defined as *T2*, is set by R1 (see above); for our project, the pulses are 5 mS apart.

Changes in acceleration change the width of each pulse (this is called *pulse-width modulation*, or *PWM*). For the ADXL202, the width changes 12.5 percent for each *g* of acceleration—both positive and negative changes. Therefore, the width of these 5-mS pulses will change by 50 percent for the entire ±2-*g* range of the device. A zero *g* state is 50 percent duty cycle. The width of the pulses is defined as *T1*. Because the ADXL202 uses a pulse-width-modulated output, rather than a linear DC output, no analog-to-digital conversion is necessary.

The ADXL202 has two axes, so it can detect acceleration and gravity changes in two axes at once. Use the device in vertical or horizontal orientation. As a tilt sensor, orient the device horizontally; any tilt in any direction will be sensed. In this position, the ADXL202 can also be used as a motion detector—determining the speed, direction, and possibly even the distance (given the resolution of the control circuitry you use) of that movement.

The control interface for the ADXL202 is surprisingly simple. Figure 4 shows the hookup diagram for connecting the ADXL202 (surface-mount chip or evaluation board) with a Basic Stamp II from Parallax (*www.parallax-inc.com*). In both cases, power for the ADXL202 comes from one of the Stamp's I/O pins, which is acceptable for testing purposes.

Listing 2 shows a short program written in PBASIC for the Basic Stamp II that allows continual reading of the two outputs of the ADXL202. The program works by first determining the period of the T2 basic pulse. It then uses the PULSEIN command with both the T1y and T1x axis signals. PULSEIN returns the length of the pulse; a longer pulse means higher *g*; a shorter pulse means lower g.

Because the BASIC Stamp II has a clock frequency of 2 microseconds, the actual time of the T1y and T1x pulses are converted to microseconds with the lines:

```
T1y = 2 * T1y
T1x = 2 * T1x
```

In T1y and T1x are the pulse widths in microseconds. These widths are then referenced to the T2 value previously obtained by the program with the lines:

```
T1y = 8 * T1y / T2
T1x = 8 * T1x / T2
```

Typical results are numbers on the order of 200 and 170 for the X and Y axes. Note that even on a flat surface the two outputs of the ADXL202 may not exactly match, due to manufacturing tolerances and differences in values for R1 and C1/C2.

The REPEAT_LOOP loop continually reads the outputs of the sensor. Without the Pause statement and Debug lines, the code loops very fast—just a few tens of microseconds—allowing you to insert other programming for your robot. Note that once the loop has begin, the value of T2 is never read again (unless the entire program is restarted). This is acceptable for low-accuracy applications like basic tilt sensing. But when higher accuracy is required, the timing of the T2 pulse train should be re-read every five or ten minutes, and even more frequently if the robot will be subjected to sudden and sharp temperature changes. The output of the ADXL202 is sensitive to temperature, so changes in temperature will affect the timing of the T2 pulse.

As the program runs, you will note that the value of the X and Y outputs will change ±50 to ±75, just by tilting the accelerometer on its sides. Sudden movement of the accelerometer will produce more drastic changes. Note the values you get and incorporate those in the accelerometer control software you devise for your robot.

Next month, we'll begin an in-depth look at the BasicX-24 microcontroller from NetMedia and discuss how it can be used in your robot creations. P

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A public service of this magazine

er you happen to be downloading; or end your session properly, by which time your caller will have given up?

What you really need is a second telephone line. An alternative is to disable Call Waiting before dialing a call with your modem. In the United States, this is done by dialing *71; your telephone company will tell you how to do it in your country. Then people calling you while you're online will hear a busy signal and will realize that your telephone is in use.

NATIONAL TECHNICAL SCHOOLS

Q *Could you help me locate National Technical Schools, which used to be on Figueroa Street in Los Angeles and has existed since 1905? They used to advertise correspondence courses in your magazine.—D. B., Kingston, Jamaica*

A Sadly, after a long and distinguished history, NTS went bankrupt and ceased operations around 1992, according to the Los Angeles Times. Old institutions seem to die off fastest when the economy is strong—one of the few disadvantages of prosperity.

WANT MODULATORS

Q *Can you tell me some sources for the little audio/video-to-RF modulators that are used in video games?—S. H., Dallas, TX*

A These modulators take audio and composite video signals and modulate them onto TV channel 3 or 4 so that the output can be fed to a TV set. As you might guess, they're plentiful, since there is one in every VCR, camcorder, and video game.

Two kinds, both priced under $5, are available from Jameco, 1355 Shoreway Road, Belmont, CA 94002, 650-592-8097; *www.jameco.com*. RadioShack's "video game switches," stock numbers 26-609 and 26-610, are actually modulators; they cost $19.99 each. Higher-performance, self-contained modulators are used with video systems; prices range up to $300 and one supplier is RadioShack's commercial division, *www.radioshack.com*. Replacements for the modulators used in VCRs are available from MCM Electronics, 650 Congress Park Drive, Centerville, OH 45459; 800-543-4330.

MOVING MESSAGE

Q *My second question is that I have an old moving-message LED display that is damaged. It was made by Dynasty of Carson, CA. I wrote to them but did not receive an answer. Do you know where I can find a circuit diagram and an EPROM for it?—F. G., Bogota, Colombia*

A Sadly, the answer is probably nowhere. Manufacturers of digital equipment seldom release this information, and when they go out of business, the knowledge disappears with them.

However, depending on what the problem is, you might be able to use standard troubleshooting techniques to fix it. The most common failures in digital equipment consist of poor connections, power-supply problems, and shorted capacitors. If the 5-volt supply seems to be shorted out, check the bypass capacitors that are located near each IC.

If you're completely stuck, write to us again giving us exact information about the make and model of the device; we'll see if a reader somewhere has one just like it.

SCANNER MEETS ITS WATERLOO?

Q *From an American, I obtained a Bearcat BC-200 radio scanner that does not work. Where can I get a schematic diagram in order to try to repair it? By the way, **Radio-Electronics** is no longer available in Belgium.—C. C., Waterloo, Belgium*

A Bearcat is now owned by Uniden. You might be able to get a schematic from Uniden Service, Inc., 4700 Amon Carter Blvd., Ft. Worth, TX 76155; 817-858-3300.

Radio-Electronics changed its name in 1992 to **Electronics Now** and has just been combined with its sister magazine, **Popular Electronics,** to create **Poptronics**. We regret that we lost you in the shuffle!

DECEMBER TYPO

In the "Q & A" column that appeared in the December 1999 issue of **Electronics Now**, the bottom of Fig. 1 on page 26 was chopped off. Although it printed only faintly, there is indeed a line across the bottom of the diagram connecting the left end of R5 to pin 7 of IC2-b.

CALL FOR QUESTIONS

"Q&A" would appreciate more questions about basic electronics, circuit design, and components. Beginners are welcome—this is your column!

WRITING TO Q&A

As always, we welcome your questions. The most interesting ones are answered in print. Please be sure to:

(1) include plenty of background information (we'll shorten your letter for publication);

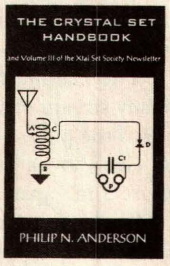
(2) give your full name and address on your letter (not just the envelope);

(3) type your letter if possible, or write very neatly; and

(4) if you are asking about a circuit, include a complete diagram.

Questions can be sent to Q&A, **Poptronics** Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735, or e-mailed to *q&a@gernsback.com*, but please do not expect an immediate reply in these pages (because of our backlog) and please don't send graphics files larger than 100K. Due to the volume of mail, we regret that we cannot give personal replies. P

INSIDE CRYSTAL SETS



An easy-to-read book on crystal set theory and construction opens vistas for novices and pros alike. Build radios like Grandpa did, do it better, and know what you are doing. *The Crystal Set Handbook*, published by The Crystal Set Society, is an authentic guide on the topic.

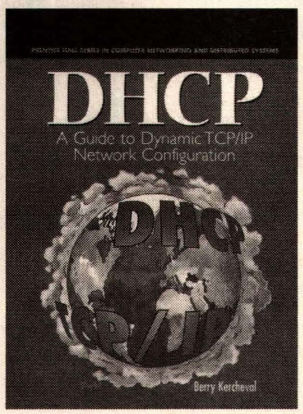
To order *The Crystal Set Handbook*, send $10.95 plus $4.00 for shipping in the U.S. and Canada only to **Electronics Technology Today Inc.**, P.O. Box 240, Massapequa Park, NY 11762-0240. Payment in U.S. funds by U.S. bank check or International Money Order. Please allow 6-8 weeks for delivery. **MA03**

NEW LITERATURE

DHCP: A Guide To Dynamic TCP/IP Network Configuration

by Berry Kercheval
Prentice Hall
One Lake Street
Upper Saddle River, NJ 07458
Tel: 800-282-0693
Web: www.phptr.com
$44.99

With DHCP, network administrators can automatically remotely configure every desktop for Internet access. Starting with an easy-to-understand description, this guide to DHCP fully explains how it works and where it's headed.

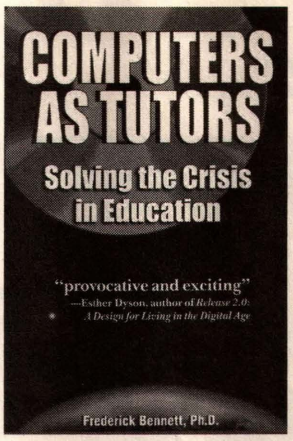


The author explains DHCP's multiple configuration options and how to choose the right ones. The latest DHCP extensions and proposals are previewed, including Secure DHCP and Reliable DHCP. A comprehensive vendor guide and the complete DHCP RFC documents are provided.

Computers As Tutors: Solving The Crisis In Education

by Frederick Bennett, Ph.D.
Faben, Inc.
P.O. Box 3133
Sarasota, FL 34230
Tel: 888-671-5112
Web: www.fabenbooks.com
$25

"Children are born with the innate desire to learn, yet over twenty-five million adults' lives are virtually destroyed by their illiteracy." The author documents how computers could enable every student, without exception, to succeed.


COMPUTERS AS TUTORS
Solving the Crisis in Education
"provocative and exciting"
—Esther Dyson, author of Release 2.0: A Design for Living in the Digital Age
Frederick Bennett, Ph.D.

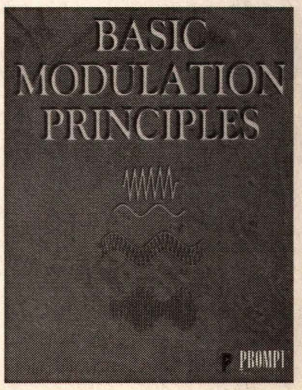
The solution, according to the author, is one-on-one computerized education. Bennett advocates pairing students with computers for individualized instruction. With computers as tutors, every child will be able to move forward at their own pace. The author envisions "Leader Teachers" who will mentor and monitor children as they progress—no student will pass through school without individual attention.

Basic Modulation Principles

by Irving Gottlieb
Prompt Publications
Howard W. Sams & Company
2647 Waterfront Parkway, East Drive
Indianapolis, IN 46214-2041
Tel: 800-428-7267
Web: www.hwsams.com
$24.95

Offering insight into the electronic equipment used today, this simple, easy-to-read guide helps readers learn about the basic ideas and implementation techniques of modulation and demodulation. With detailed descriptions and schematics, this book covers everything from the nature of frequency modulation and spectra effects of modulating signals in AM to bessel functions and the basic building blocks of AM and FM transmitters. Designed for hobbyists or electronics technicians, this book is a useful practical reference.

Organized into four sections, the book covers amplitude modulation; single-sideband, double sideband, and vestigial-sideband modulation; frequency and phase modulation; and demodulation. Following each section is an illustration gallery including the graphs, schematics, and waveforms referred to in the text.



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DHTML & JavaScript

by Gilorien
Prentice Hall
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Web: www.phptr.com
$42.99

This complete task-oriented tutorial delivers thorough coverage of JavaScript theory operation and functions. It's a detailed reference to JavaScript syntax, and a library of over 400 working examples that show exactly how to build innovative Web sites with Netscape's hottest technologies. The accompanying CD-ROM contains all these examples, as well as two hyper-linked versions of the book.

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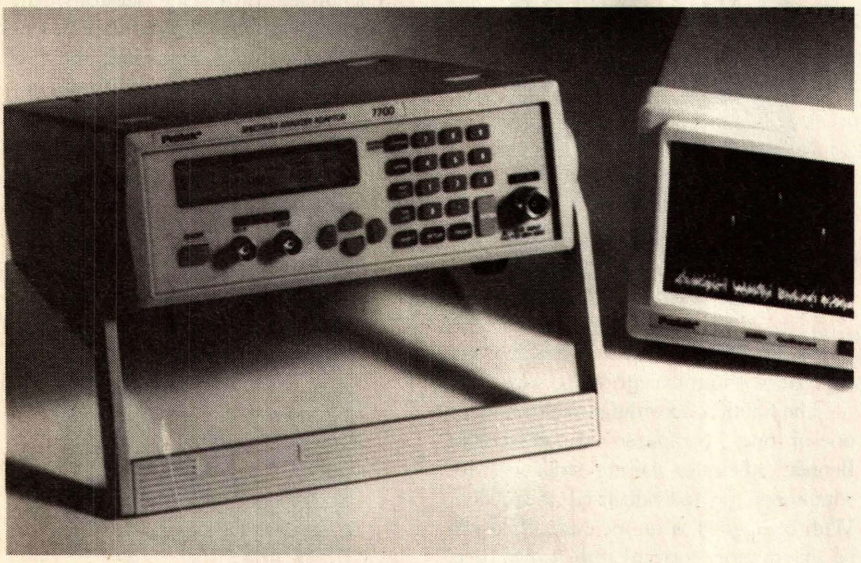

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DESIGNED WITH ADVANCED DSP technology, the digitally synthesized *Spectrum Analyzer Adapter Model 7700* converts any dual-trace oscilloscope into a 1-GHz spectrum analyzer with all the features and functions needed to make precise frequency and power measurements. The Model 7700 can be used to check and troubleshoot all IF and RF circuitry in wireless products, such as two-way radios, PCS and cellular telephones in addition to cable TV systems, wireless remotes, wireless mics, and video equipment.

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The Model 7700 adapter offers a Zero span feature for monitoring in the time domain the amplitude of a carrier signal. This mode displays any variations in the carrier amplitude over a period of time, allowing long-term trends and carrier irregularities to be observed. It also provides frequency spans from 2KHz/ Div to 100MHz/Div. The 2KHz/ Div span is useful for testing RF output type sensors, where a change in the sensor input value results in a proportional change in RF carrier deviation. Other features include an average noise level of 140dBm/Hz and a wide 120dBm input measuring range.

The Model 7700 Spectrum Analyzer Adapter has an MSRP of $1600.

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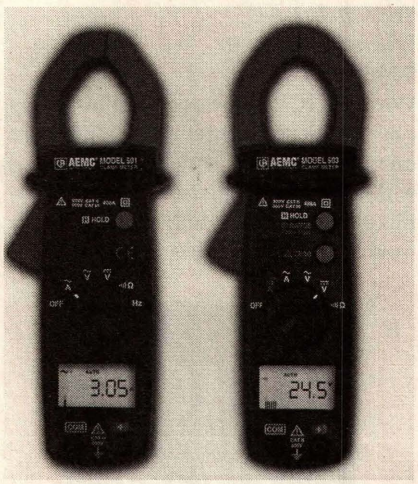

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Features of these meters include accuracy to 1%, a large easy-to-read 4000-count display, and a 42-segment bargraph. Measuring 7.6 by 1.97 by 1.1 inches, the tough durable meters are compact and easy to use in tight places.

Models 501 and 503 Clamp-On Meters have list prices starting at $99.

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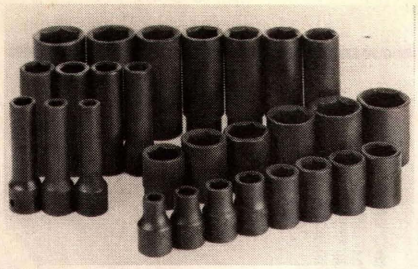
The Fractional Impact Socket Set



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(#4051) and the Metric Impact Socket Set (#4053) cost $229.95 each.

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The camera has a 1/3-inch interline CCD image with no audio. It provides a high resolution of 430 TV lines, 0.1 Lux for the B/W model and 400 TV lines, 2 Lux for the color model. The compact camera measures 3 1/2 by 2 1/3 by 2 1/3 inches. Both models require a 12 volt DC power supply and come with mounting hardware.

The WR-700 Weather-Resistant Camera has an introductory price of $89 (B/W model) and $179 (color model).

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SERVICE CLINIC

(continued from page 47)

well as the idler clutch—if it weakens, then the idler wheel does not press against the appropriate reel with enough force to grip. Is the VCR a top loader or a front loader? On a top loader, you should be able to trick it into playing a non-existent tape by covering up the end-of-tape sensor or microswitch. This may permit you to see what is going on.

If the VCR is a front loader, then it is tougher. You need a cassette cheater like the ones described in an earlier column in this series. Then, with the cheater in place happily fooling the VCR, feel the spindles while the machine is operating. In FF or REW, you may find that they are not being driven or are being driven very weakly. Try to determine if the idler is even being pushed into position or is hung up on something. If there is any chance that it is the idler tire, try removing it, turning it inside out, and reinstalling it. The relatively protected inner (now outer) surface may grip well enough to confirm the diagnosis.

Quit While You're Ahead—Abort Fast Forward Or Rewind

In this case, the tape starts to move—possibly at a reasonable speed—but then may shut down. The problem may also seem erratic or may depend on the tape being used. Make sure that the tape is not the problem—try another one. If the VCR starts the operation (as evidenced by whirring sounds and the tape counter changing numbers) but at some point aborts and shuts down, there are several possibilities. It could be a worn idler tire, worn or broken idler clutch, bad belt, or lubrication problem. With instant start transports—where the tape is maintained around the video head drum for all but the fastest rewind, there could be other control problems as well.

If the tape starts fast-forwarding or rewinding properly (as seen from a visual inspection with the cover off), but the tape counter does not change value and the unit then shuts down; a reel-rotation sensor problem is likely. We'll deal with sensors in a future Service Clinic.

If the operation aborts at the same location on only certain tapes, there could be pinholes in the tape oxide coating allowing light to pass through and confuse the sensors. This happens mostly with T160 or old well-worn tapes. If you can locate the problem area, you can try indelible ink on the *non*-oxide side of the tape but ***DO NOT*** use adhesive tape or glue. It's probably best to discard the tape. Otherwise, all you can do is to live with its behavior.

Noisy Rewind or Fast Forward

While these operations are never exactly quiet, when grinding or squeaking noises are evident, it is time to at least consider the possibilities. Confirm that the same thing happens with more than one cassette. It could simply be that you have one defective tape. *(Portions of the following text were contributed by Alan McKinnon (alan.mck@pixie.co.za) and Oldguyteck (edward.croteau@the-spa.com).)*

There are several types of noisy rewind:

A high-pitched squeak: Dirt and/or dried or lost lubrication on reel spindles. Remove both reel tables and clean and lubricate the shafts. On older machines, you often find this as well on idler pulleys.

Periodic 'eek-eek' noise: Check for an out-of-round rotating part rubbing on something. No pat answers here; you have to open your eyes and look.

A grating metal on metal noise: Sounds like car brake pads that should have been changed 5000 miles ago is always the capstan rubbing on its bearing. The only cure is a new motor. Ignore those that tell you to strip and clean the bearing. I've tried this trick at least ten times on different machines—it won't last. If a capstan motor is worn enough to howl, the shaft and bearing are way beyond repair.

Cassette not seating properly and/or tape path alignment problems. Press down on the cassette during REW or FF and see if it shuts up.

Brake levers not disengaging completely, pads worn, or misadjusted.

Missing fiber washers (who worked on the VCR last?). Worn, broken, or distorted gears; other lubrication or dirt problems; etc.

Bad bearings in main motor (usually found in older VCRs).

The list goes on and on. In the end, the only way to narrow down the problem will be with your eyes and ears!

That's it for this time. Next month, we will look into play and record problems. Until then, check out my Web site at *www.repairfaq.org*. I welcome comments (via e-mail only to *sam@stdavids.picker.com*) of all types and will reply promptly to requests for information. See you next time!

CHARLES D. RAKES

Plug In, Turn On, and Power Up: Wall-Mounted Power Supplies

Well! I m glad to see that you survived last month s foray into the dangerous world of high voltage. This month, I thought I d head to the other end of the voltage spectrum, so get ready for some circuitry fun as we go on an electronic treasure hunt for "wall warts," power adapters, wall chargers, and other direct plug-in AC-power providers. I ll bet that if you search around your digs, you'll discover several unused wall-mounted transformers that once provided power to a variety of electronic devices such as telephone-answer machines, cassette recorders, CD players, radios, battery chargers, among others. Here's the reason for the search: Those little beasts can be turned into handy and inexpensive power sources for numerous circuit experiments and future projects.

Most of the wall transformers, as found, are not suitable for general power-supply service because they were designed to power a specific electronic device, which often contained the filtering and regulation components necessary to complete the power-supply circuitry. The majority of the wall transformers only output a raw DC voltage that's usually much higher in value than the listed output voltage. A few are nothing more than a step-down transformer in a plastic housing with an AC output. Be aware that what is listed on the case of the unit is not necessarily what is available at the output.

The majority of wall adapters contain a "class II" transformer. This type of transformer has a high-resistance primary winding that is designed to burn out rather than to burn up. The primary winding is usually wound with fine copper wire, and when the secondary winding is overloaded or shorted, the primary heats up and after a period of time burns open. The housing usually heats up, but normally not to the point where it would be painful to touch, before the primary opens. If you measure the primary winding DC resistance of about a dozen random wall transformers, you'll find that they measure between 90 and 350 ohms. If a resistance of only a few

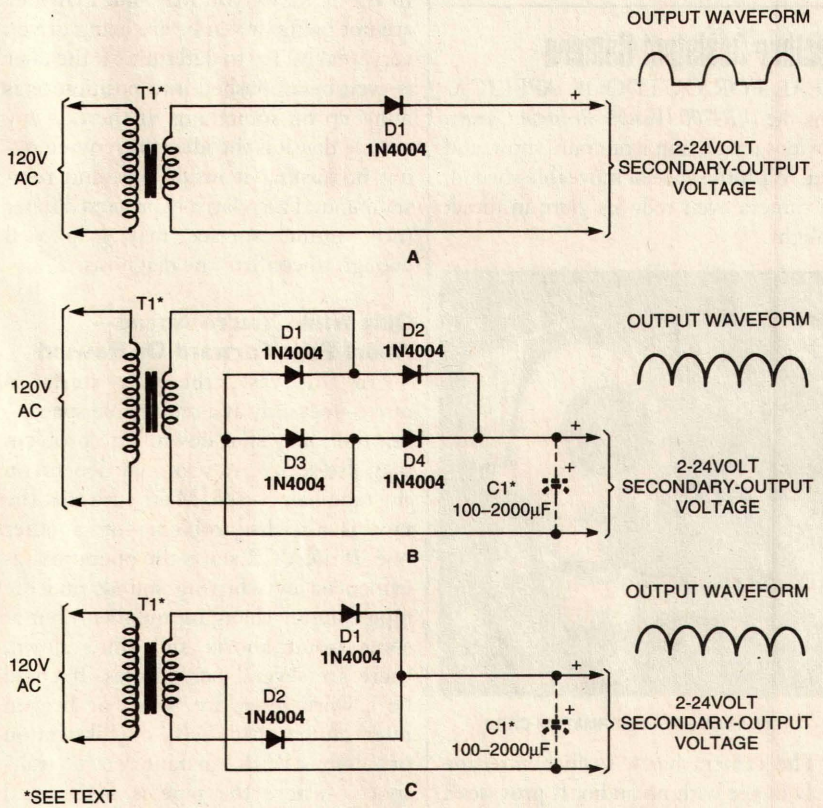

Fig. 1. Basic wall-mounted transformers that output a DC voltage usually come in one of three flavors: a half-wave output with a single diode (A), a full-wave output (B), or a full-wave output that uses a center-tapped transformer (C). Sometimes (but not always) a capacitor is included to smooth the output.

PARTS LIST FOR THE BASIC WALL TRANSFORMER (FIG. 1)

C1—100–2000-µF, 35-WVDC, electrolytic capacitor
D1–D4—1N4004 silicon-rectifier diode
T1—Class II transformer (see text)

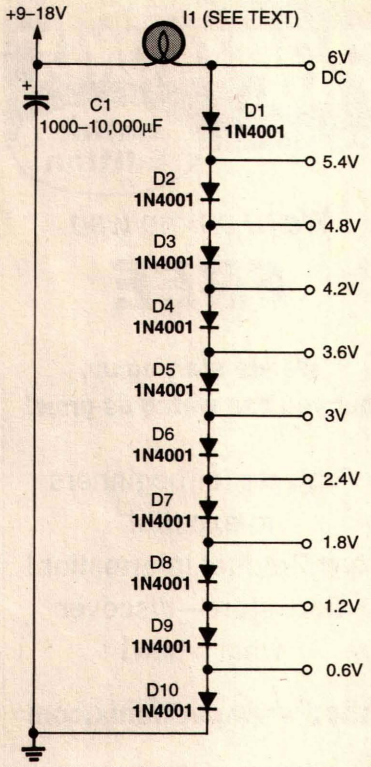

Fig. 2. A simple form of shunt regulator uses a series of silicon diodes. The node of each diode is 0.6 volts lower than the one above it. Some form of load is needed to limit current through the diode string; here, an incandescent lamp is used.

PARTS LIST FOR THE BASIC SHUNT REGULATOR (FIG. 2)

C1—1000–10,000-µF, 25-WVDC, electrolytic capacitor
D1–D10—1N4001 silicon-rectifier diode
I1—3- to 6-volt incandescent-light bulb (see text)

ohms is measured, it's a good possibility that the transformer is not a class II type or that the primary winding is shorted. In any case, be safe and unplug it when not in use!

It's What's Inside That Counts

Let's take a look at the basic "innards" of some typical wall transformers. In Fig. 1A, we have the least desirable type of wall-transformer arrangement that would be suitable for power-supply duty. A single rectifier is used supplying a half-wave DC output without any internal filtering. In order to turn that into a useful supply, a very large-value electrolytic capacitor would be needed across the output. Also, to help make up for the circuit's inefficiencies, a voltage regulator should be included. A wall transformer with only an AC output would be a much better choice; a full-wave rectifier circuit could be added externally.

Our next choice, Fig. 1B, is probably the most desirable type available for power supply use. The output is full-wave rectified with internal filtering. Additional filtering capacitors and a regulator circuit can turn this type of unit into an excellent power source. The wall transformer in Fig. 1C uses a center-tapped transformer with a full-wave rectifier and internal filtering, which is also a desirable choice for power supply use.

An example of a wall transformer similar to the one in Fig. 1C, with a listed output of 3 volts DC at a maximum current of 1 amp, actually had an unloaded output of 6.8 volts; when loaded to a current of 1 amp, the voltage dropped to about 2.8 volts. Adding a 2500-µF electrolytic capacitor across the output increased the voltage to slightly over 3

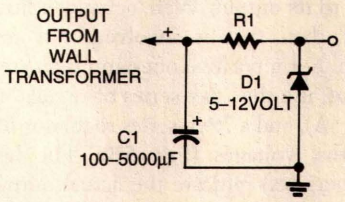

Fig. 3. A more sophisticated form of shunt regulator uses a Zener diode for regulation; those devices are available in several voltages. The lamp load in Fig. 2 is replaced with a resistor. As with most wall-transformer-based power-supply circuits, an electrolytic capacitor smoothes out any ripple present in the transformer's output.

PARTS LIST FOR THE ADVANCED SHUNT REGULATOR (FIG. 3)

C1—100–5000-µF, 35-WVDC, electrolytic capacitor
R1—Resistor (See text for value)
Z1—Zener diode (see text)

volts. Those simple tests can usually supply enough information as to what's inside a particular unit to indicate what needs to be added externally for it to be a useful supply. If there's any doubt about the type of internal rectifier circuitry, use a digital ohmmeter in the "diode" position (a common feature found on most newer digital multimeters that reads the diode's forward voltage drop) and check

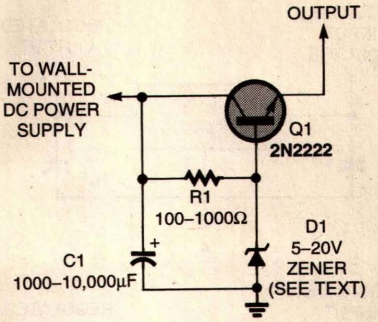

Fig. 4. A series regulator is more efficient than the shunt variety. Here, the amount of current passing through Q1 is regulated by D1. The voltage value of D1 must be 0.6-volts higher than the voltage that will be available from the emitter of Q1.

PARTS LIST FOR THE DISCRETE SERIES REGULATOR (FIG. 4)

C1—1000–10,000-µF, 25-WVDC, electrolytic capacitor
Q1—2N2222 or TIP3055 NPN transistor (see text)
R1—270–1000-ohm resistor (see text)
Z1—5–20-volt Zener diode (see text)

across the output terminals. If a reading of approximately 0.550 is obtained, the circuit is most likely a full-wave-rectifier circuit similar to the one in Fig. 1C. Of course, it could also be a single-diode circuit like Fig. 1A. To be sure which type of circuit is inside, connect an oscilloscope across the unit's output to see whether the output is half-wave or full-wave. Figure 1 has output waveforms for each type of circuit as a guide.

If the ohmmeter test reads 1.000 or greater, the rectifier circuit is most likely similar to Fig. 1B.

Shunt Regulator

A quick and inexpensive shunt-voltage-regulator circuit (see Fig. 2) can be constructed by connecting a number of silicon diodes in series. Just divide the desired output voltage by 0.6 and use that number of diodes in series. If 6 volts is required, connect ten diodes in series and feed the string through either a light bulb or resistor. The lamp or resistor value used will depend on the transformer's output voltage and the regulator's output voltage and current. Also, add a few thousand microfarads of capacitance across the transformer output. One advantage that this simple regulator circuit offers is a stepped output voltage that increases from 0.6 volts to 6

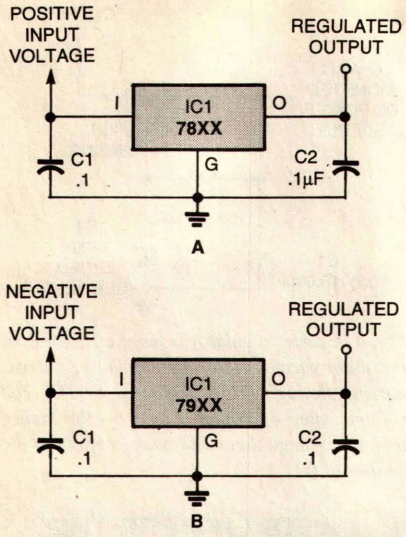

Fig. 5. The series-regulator circuit of Fig. 4 is conveniently packaged in a three-terminal integrated circuit that is easy to use. Both positive (A) and negative (B) versions are available.

PARTS LIST FOR THE IC SERIES REGULATOR (FIG. 5)

C1—1000–10,000-µF, 35-WVDC, electrolytic capacitor
C2—0.1-µF, 50-WVDC, ceramic-disc capacitor
IC1—78xx or 79xx-series fixed-voltage regulator, integrated circuit (see text)

volts in 0.6-volt steps. While it is not an ideal voltage-regulator circuit, it will certainly work; for many applications, it an ideal solution.

Shunt Regulator, Take Two

Another simple shunt-regulator circuit is shown in Fig. 3. A Zener diode replaces the string of silicon diodes and a resistor is used as the current-limiting component. As we've done before, an additional filtering capacitor is added to the wall transformer's output. The zener's voltage rating and R1's resistance values are determined by the transformer used and the desired regulated-output voltage.

Series Regulation A Piece At A Time

A simple series-regulator circuit that can be built with discrete parts for a buck or two is shown in Fig. 4. A 2N2222 transistor can be used as the series regulator if the required output current is 25 milliamps or less. For outputs up to about 0.5 amps, use a TIP3055 plastic power transistor and a heat sink for Q1. The output voltage will be about 0.6 volts less than what the Zener used due to Q1's base-emitter voltage drop. The value of R1 will be between 100 and 1000 ohms, depending on the particular input voltage and the Zener/transistor combination.

As a starting point, try using a 1000-ohm resistor with the 2N2222 or a 270-ohm resistor with the TIP3055. Capacitor C1 can be an electrolytic capacitor with any value between 1000 and 10,000 µF at a working voltage higher than the unloaded output voltage of the transformer. Here, bigger is always better. If you are concerned about getting all of the component values just right for this circuit and don't feel comfortable experimenting, then the next, almost universal, circuit solution is right up your alley!

IC Regulators

The circuits in Fig. 5 make the job of turning a "wall wart" into a wallflower as easy as connecting a fixed-voltage regulator to its output. Well, actually a little more than that is involved, but not much. For a positive one-amp regulated output, use the 78xx-series of regulators (Fig. 5A), and a 79xx-series regulator for negative voltages (Fig. 5B). The last numbers (xx) indicate the actual output voltage. For example, the 7805 is a 5-volt positive regulator while a 7912 is a 12-volt negative regulator.

Those series of IC voltage regulators can be found in most any electronic-parts store or mail-order house for less than two bucks each.

Two capacitors complete the IC-regulator circuit. Any type of 0.1-µF capacitor can be used for C2; C1 is a large electrolytic capacitor to smooth the transformer's output. Any value between 1000 and 10,000 µF will do. Note that the polarity of C1 should match the voltage polarity—especially when working with a negative-regulator circuit!

It's also a good idea to bolt the IC regulator to a piece of metal or to a factory heatsink to keep the operation cool. Don't forget to use a mica insulator and a dab of heatsink grease; regulator tabs are usually not connected to the ground terminal.

It looks like our allotted space is just about filled for this visit, so go forth and dig out all of those old accessory adapters and get busy turning them into useful power sources.

Good circuitry! P

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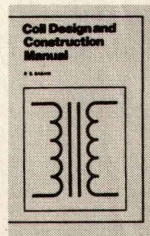

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TECH MUSINGS

DON LANCASTER

Synchros and Selsyns And Accelerometers...Oh, My!

I just picked up some interesting 1970's military accelerometers. They consist of a fist-sized magnetically damped pendulum coupled to a syncro transmitter. These do seem to offer sub-g sensitivities. Yeah, solid-state accelerometers from Analog Devices (check out their ADXL05 in particular) or Motorola or others are getting fairly cheap, stable, and quite sensitive. However, these older mechanical beasties might still lead you to lots of interesting robot navigation, physics demos, racing car apps, or even military collectibles. With modifications, they might also make dandy inclinometers or levels. Figure 1 shows us what a typical unit looks like. More details on these are now posted to my *www.tinaja.com/bargms01.html.* All of which reminded me that it is way past time for us to look at...

Servos, Selsyns, and Friends

A lot of the stuff we routinely do with cheap electronics these days had to be handled at one time by special and expensive mechanical devices. A *servo* is any system that uses position or other feedback to gain accuracy. The feedback of most closed-loop systems improves precision but does so with price and stability problems. Usually, some position, velocity, or other factors is measured and compared against your current goal—generating an error signal. The servo then seeks to minimize (or null out) errors. A servomechanism is a servo that involves mechanical motion of some sort. A servomotor is just any motor or mechanical actuator that can be run in either direction and can be safely stalled in any position.

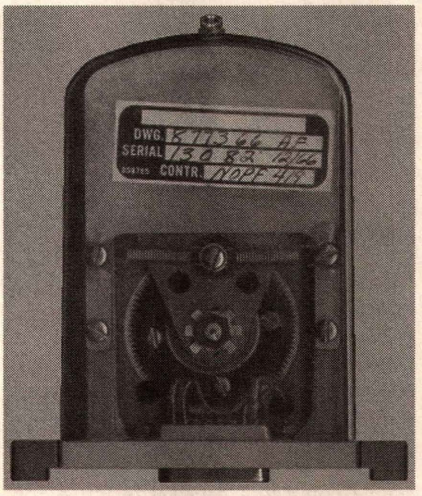

Fig. 1. An older military accelerometer that makes use of a pendulum coupled to a synchro transmitter is shown here.

A *selsyn* is a system that consists of two or more motor-like devices that are intended to control or sense shaft positions. These might be true servo closed-loop or simple open-loop devices. Selsyns played a major role in all WWII ships and aircraft for position control. They are still used for ham antenna sensors, rugged industrial needs, or to measure wind speed and direction. Useful sources for selsyn parts are Fair Radio, Servo Systems, or C & H Sales.

Figure 2 shows a typical selsyn setup. A synchro transmitter consists of a three-phase rotary transformer. The single-phase rotor is driven from a 400-cycle (aircraft) or a 60-cycle (ship or land) source. Three sensing windings physically spaced 120 degrees around the stator output three sine waves whose values are related to the shaft angle. A second device

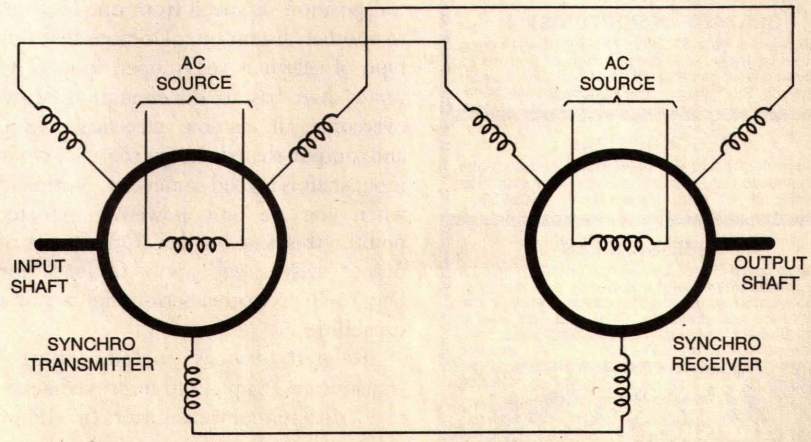

Fig. 2. A selsyn system consists of a synchro transmitter and a synchro receiver. The output shaft position follows the input.

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can be connected backwards across the three outputs. Its shaft will automatically follow the input shaft position. Thus, a pair of synchros could send any mechanical position or speed from one location to another distant one. Do note that this type of selsyn is really open loop. The input shaft has to do enough work to overcome all friction, electrical losses, and output-shaft-load inertia. So, your input shaft is loaded somewhat. Normally when you are only powering a meter pointer, this is no big deal. Other types of output selsyns will apply feedback for flap, rudder, or other serious tail-twisting capabilities.

Related devices include control transmitters (to pick up improved accuracy), differential transmitters (to add or subtract two shaft angles), or receivers (handy for shaft position displays). A *synchro resolver* does the calculations needed to find an angle's X and Y components or to provide a digital display. Fancier selsyn combinations can do amazingly sophisticated analog trig calculations or similar tasks.

A useful synchro application-guide tutorial is available at *www.litton-ps.com/DataSheetList.htm*. Figure 3 is a photo of a standard synchro transmitter. Older sizes are usually measured in tenths of an inch. Thus a "size eight" selsyn is 0.8 inches in diameter while the "size fourteen" safely clears an inch-and-a-half space. Let me know if you need any of these to play with.

Dealing with 400 Hz

Military and other aircraft selected 400-Hz as an operating frequency because the size and weight (and thus the horsepower per pound) are much better than the usual 60-Hz utility

Fig. 3. A Synchro transmitter is used to sense shaft position.

power. The short transmission range of higher frequencies is not a factor in most airborne applications. Working 400-Hz power used to be a pain, but these days a PIC, some coils, and a few power semiconductors easily generate it. Mechanical "dynamotor" 60- to 400-Hz converters are readily available as military surplus at *www.tinaja.com/ barg01. html* and a few other places.

This is a perfect way to apply my new magic-sinewave techniques that you can find described in detail at *www.tinaja.com/magsn01.html.* Can you run a 400-Hz device at 60 Hz? If you try this one-on-one, smoke and fire are certain to result. The lower winding inductance draws much higher current at a set voltage, saturates the iron, and burns up. Do not ever plug any 400-Hz device into the same voltage 60-Hz power line!

Few folks have noticed a sneaky workaround. Flux density is the name of the game. A 400-Hz device will usually run just fine on 60-Hz if you lower the voltage to 60/400ths or 0.15. The same current will produce the same magnetic flux, and the beast should remain happy. Naturally, the power and speed of a motor will be miniscule if you try this, but it is possible that it will still end up useful. A 400-Hz iron is often cheap.

Thankfully, in the case of a selsyn transmitter, these days you can use higher impedance electronic loads that you route to a PIC or whatever. A 12- or 15-volt 60-Hz AC supply should work just fine. Thus, selsyn synchro transmitters may still be able to hold their own against encoders for some experimental applications—especially for measuring wind speed and position or for ham antenna sensing—and just may offer cost and reliability advantages.

Selsyns may seem dated, but servo and feedback concepts definitely are not. With this in mind, I have gathered together some of the better books on this subject for you as our resource sidebar. More details on all of these titles can be found at *www.tinaja.com/amlink01.html.*

Listening to Bats

Bats make use of utterly amazing ultrasonic-sonar systems. Their echolocation gets used both in a low-resolution mode for navigation and in high resolution to chow down on flying bugs. Considering the weight, power, resolution, and efficiency, a typical bat navigation system is some eleven orders of magnitude better than the best of military radar systems. Eons ago, the bats discovered the chirp secret to high-resolution radar. Namely, that a long swept frequency sine wave could be collapsed into the narrow pulses needed for high-resolution distance measurements. Collapsing can be done by taking the Fourier transform of the swept return signal. However, bats more than likely use an acoustical-delay network having a linear time-versus-frequency delay characteristic. Details are shown in Fig. 4.

Intuitively, sending any swept FM sinewave into a linear time-delay versus frequency-network stalls the higher frequency parts more than the lower ones, so they all pile up on top of each other and form a narrow pulse. Mathematically, you have done the frequency-domain to time-domain conversion through Fourier, Wavelet, or some similar transformation.

The sweep rates and frequencies depend on the species and whether the bat is in travel or chow mode. Typical sweep limits might be 20- to 40-, or 30- to 60-kHz, with repetition rates going as high as 200 per second. You cannot directly hear most of a bat's chirp, because of its ultrasonic frequencies and wide bandwidths. Instead, one of a number of sneaky schemes can be used to listen in. One of the simplest is pick up the bat's chirp with an ultrasonic alarm transducer. You then amplify and limit the signal and divide it down with a CMOS binary counter such as a 4040. The hard limiting removes many subtleties of the signal, but still lets you determine the presence and possibly the species of the bat.

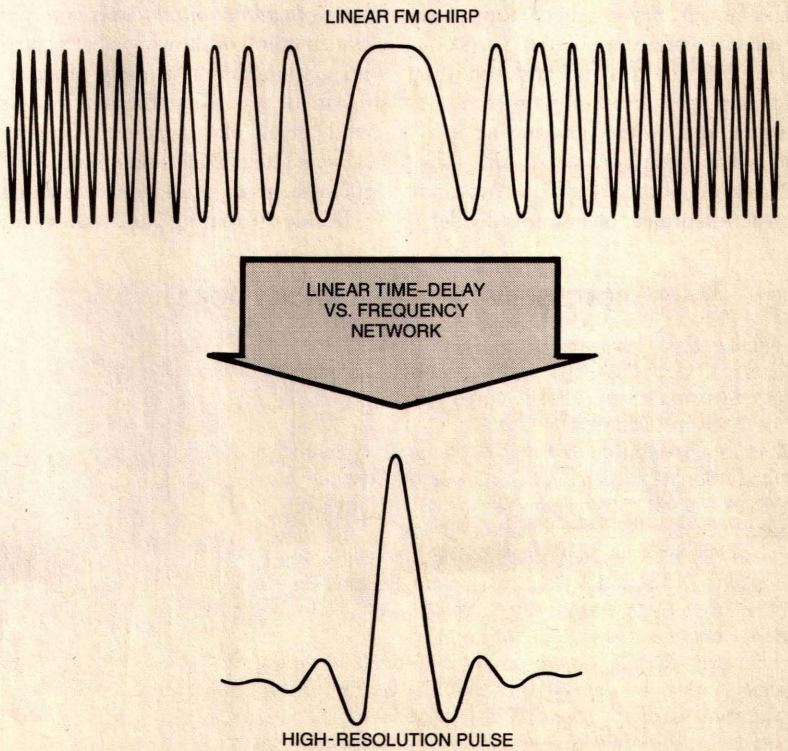

Fig. 4. A bat's chirp uses this sophisticated Fourier Transform scheme to dramatically improve its navigational resolution.

```
% POSTSCRIPT "404" ERROR EXTRACTOR/REPORTER
% ==========================
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% (520) 428-4073 don@tinaja.com http://www.tinaja.com
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% This PostScript-as-language routine reads an ISP log file and extracts all
% "404" or FILE NOT FOUND entries into a separate analysis file.

% To use this program, enter the full path sourcefile and target file names
% and keyphrase below and resave. Then distill the file.

% Note that a NO FILE PRODUCED message is normal and expected.

% IMPORTANT: Be sure to use "\\" when you mean "\" in any PostScript string!

/sourcefilename (C:\\medocs\\logfile.txt) def      % sourcefile
/targetfilename (C:\\medocs\\e404file.txt) def    % output file
/searchphrase (- 404) def                         % term to filter on
/workstring 2000 string def                       % string holds analysis line
/ws {writefile exch writestring} def              % create output file object
/addtooutfile {ws (\n) ws} def                    % add line to output file
/endoutfile {(\n\n) ws
    writefile closefile} def                      % close file when done

% checkline tests to see if a dash followed by a space and a 404 is present...
/checkline {dup searchphrase search {pop pop pop addtooutfile}{pop pop} ifelse} def

% /startoutfile creates an output file object...
/startoutfile {targetfilename (w+) file /writefile exch def(\n\nLines containing ) ws
searchphrase ws ( in document ) ws sourcefilename ws (:\n\n) ws} def

% Main loop reads one logfile line at a time for processing...
/grabphrase {sourcefilename (r) file /workfile exch def startoutfile
{mark workfile workstring readline {checkline}{exit} ifelse
cleartomark} loop endoutfile pop} def

grabphrase                                        % This actually does it

%% EOF
```

Fig. 5. Postscript code to extract 404 log error messages.

The heterodyne methods can also be used if you down convert the bat's signal to the audio range where you can listen to it. A fancier, newer scheme known as *time dilation* works even better. You sample every 16th chirp signal and feed it to a dual-port memory. You then read out the signal at a 1/16 rate, converting it to audio while retaining all of the full-amplitude details. A great Tony Messina construction project on a simple divider-style bat detector can be found at *pw1.netco m.com/~t-rex/BatDetector.html.*

Other technical bat resources are at *life.csu.edu.au/batcall/abs/links.htm*. The classic method of showing a bat's chirp is with a sonograph. An early pioneer in this field was Kay Elemetrics. Still found, of all places, at *www.kayelemetrics.com*. Their DSP Sonograph Model 5500-1 seems to be an industry standard.

Besides listening to bats, various counting and monitoring schemes are often used. They can involve anything from clickety-clack manual counters to the most elaborate of 3-D multi-target image processing. Bat guano analysis can tell you a lot about pollution, climate, and other environmental changes as well. I am sometimes involved in an annual trek to Arizona's Falcon Creek Bat Cave to sample each year's guano deposits and return them for lab analysis. **WARNING: Before getting into this by yourself, be certain to read up on histoplasmosis**. Much more about Fourier and correlation appears in MUSE90.PDF and ACK54.PDF. More on CMOS counters and such can be found in my *CMOS Cookbook.*

The best place to go for accurate bat info is BCI, an acronym for Bat Conservation International. You can visit the Web site at *www.batcon.org*. For some really strange reasons, bat enthusiasts and cavers tend to go together. Maybe it is because they both sleep upside down. Thus, the National Speleological Society at *www.caves.org* also has all sorts of information and bat-related activities. Local chapters of the NSS are often called *grottos*. A typical state will have a dozen. Chances are that several are located near you.

Avoiding 404s

Preventing Web site errors can be a thankless and never-ending task. We saw last month how there is a great freebie Dr. HTML web service up at *www.imageware.com/RxHTML* or by way of my home page HTML button at *www.tinaja.com*. This is great for checking everything from links to spelling to programming syntax. We also saw how to extend this service to Acrobat .PDF files. A 404 or File Not Found error is any file that you cannot provide on your Web site. Some of these will be plain old mistakes visitors have made or else snooping attempts to hunt for pornography or to deduce your site structure. Others might be administrative related. For instance, the way my ISP has the site search set up, unnecessary errors are reported. The search succeeds and the visitor is happy, but the error is mysteriously generated anyway. A third source of errors is your own mistakes. These may be difficult or impractical to repair. They are often items such as an URL mention in some newsgroup, on a printed page, or a misquote. Nevertheless, the final error sources are your own mis-

SOME SERVO AND FEEDBACK BOOKS

Analytic Feedback System Design (Peter Dorato)
Automatic Control:The Power of Feedback (T. Djaferis)
Control System Design Guide (George Ellis)
Control System Dynamics (Robert Clark)
D.C. Motors Speed Control Servo Systems (R. Greene)
Design of Control Systems for DC Drives (A. Buxbaum)
Feedback Control of Dynamic Systems (Gene Franklin)
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Force and Touch Feedback for Virtual Reality (G. Burdea)
Introduction To Feedback Control Systems (Pericles Emanuel)
Introduction to Servomechanism System Design (W. Humphrey)
Modern Control Systems (Richard Dorf)
Nonlinear and Optimal Control Systems (Thomas Vincent)
Principles of Process and Servo Control (D. Senko)
Quantitative Feedback Theory (Constantine H. Houpis)
Schaum's Outline of Feedback and Control Systems (Schaum's)
Synchro and Resolver Conversion (Georffrey Boyes)
For more book details, see *www.tinaja.com/amlink01.html.*

takes that you can correct.

These you must ruthlessly stomp out when and as you find out about them. You find your errors by reading the raw log files that your ISP should be providing you. Note that most statistics software only does error summaries instead of providing the needed details. Errors can be found by searching the log files for a "*404*." Of special interest is their referral information in the same line. This tells you where your visitor came from. When they arrived from another of your pages, you have a great clue to exactly when and where the error came down. A reasonable goal should be to keep your 404-error rate under one half of one percent.

Our PostScript-as-language code for this month reads your log file, extracts the useful parts of each 404-error line and reports them back to you. This can be a convenient way to improve your web stats. Details are shown in Fig. 5.

You should first enter a PostScript program into a word processor or text editor and modify it for your intended use. You then save the file as a standard ASCII text file. The file is then sent to Acrobat Distiller or GhostScript. Extracted output error lists are reported onscreen in the log file and are saved as separate files for later analysis and correction. More on PostScript-as-language in *www.tinaja.com/post01.html.*

New Tech Lit

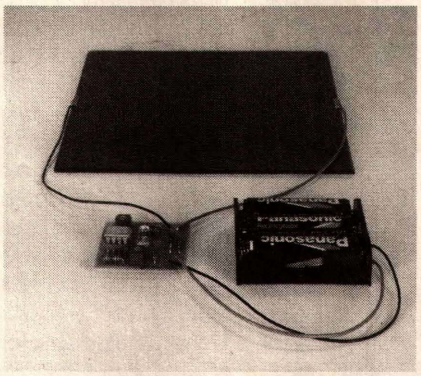
Microsoft has recently upgraded their already outstanding TerraServer site. Topographic maps have been added to their aerial photos. They are also in the process of adding bunches of photo coverage with accuracy to one meter. You can find all this up at *www.terraserver.microsoft.com.* On the other hand, you can just click on the AERIAL button up at my *www.tinaja.com.* A monster "my-database-is-bigger-than-yours" feud seems to be going on between the TerraServer folks and the online IBM patent resource up at *patent.womplex.ibm.com.* Both of these clearly seem to be moving up well into terabyte territory. More on the patently absurd is up at *www.tinaja.com/patnt01.html.*

From Micro Linear comes a new CD on their integrated circuit line. Useful application notes are included on lamp ballast and intelligent battery management. Free info on CAD (*c*omputer-*a*ided *d*esign or *d*rafting) can be found up at *www.cadprimer.com.* Engineering links are provided for you at *www.spacey.net/davis/frames.html.* Or hit the LEROY button on my home page at *www.tinaja.com.* The SETI-at-home project has now shattered all records for the largest computing project of all time. It is now racking up over one millennia per day of computing time! You are invited to become a participant by picking up details at *setiathome.ssl.berkeley.edu.*

Our featured trade journals for this month: *BookTech*, *Print on Demand Business*, and *Digital Graphics*, with coverage of emerging and exciting new self-publishing opportunities. More information can be found at *www.tinaja.com/bod01.html.* P

NOCTURNAL FLAME

(continued from page 28)



The completed Nocturnal Flame is ready to capture the sun's energy for you.

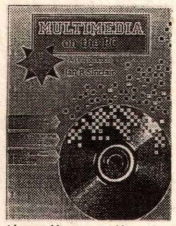
type of cell, solder two lengths of wire to the outside of each channel clip. Scrape the silver backing from the back of PC1 where the channels will attach. Bend the edges of the channels slightly inward so that they will fit snugly on the solar cell and slide them on. Remember, solar cells are fragile; be careful not to break the glass.

When the Nocturnal Flame is completely assembled, check your work over for errors such as bad solder joints, wrong components, or other similar mistakes that seem ridiculous or embarrassing once they are found.

Place PC1 in a window or under a bright light. Turn R5 and R6 fully counterclockwise. That will set the PWM level to 0 and disable LED1. Measure the voltage from the solar cell. If the light is bright enough, you should at least see a couple of volts. Also measure the battery voltage at the positive terminal of B1. You should see 0.7 volts less than the solar cell's output voltage. Depending on the state of the batteries and the intensity of the light source, there should be a couple of volts, and it should be rising by a few millivolts very slowly. Keep the cell under the light for 10 minutes or so until the batteries achieve a partial charge. Now turn R6 fully clockwise. That will set the PWM level of LED1 to full. Turn R5 slowly clockwise. If everything went well, LED1 should come on somewhere before the pot hits the clockwise stop. If it did not come on, check the component placements and connections.

Operation. The operation of the Nocturnal Flame is very straightforward. Point PC1 at the sun to charge B1 and wait until dusk. When it is dark enough for you to want LED1 to come on, adjust R5 clockwise until LED1 lights. Adjust R6 for the desired brightness level.

Build one or more Nocturnal Flames and use them as accent lights around your deck, to highlight steps or paths around your home, as night lights in your home, or even just for custom lighting effects. P



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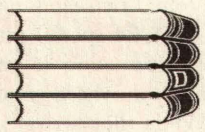

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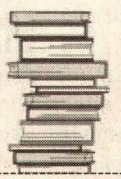

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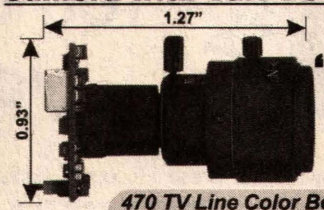

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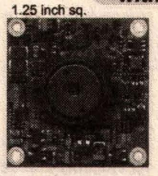

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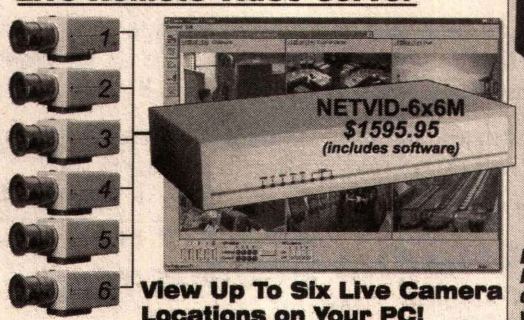

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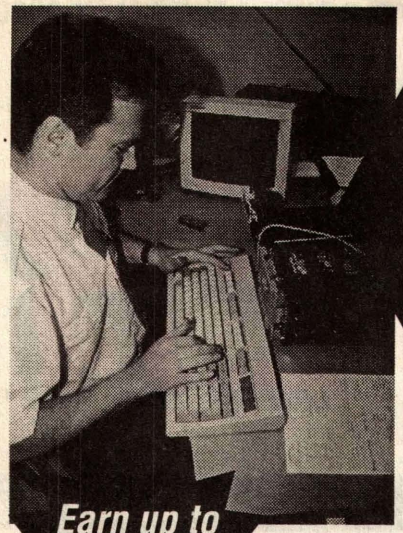

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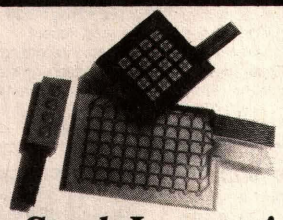

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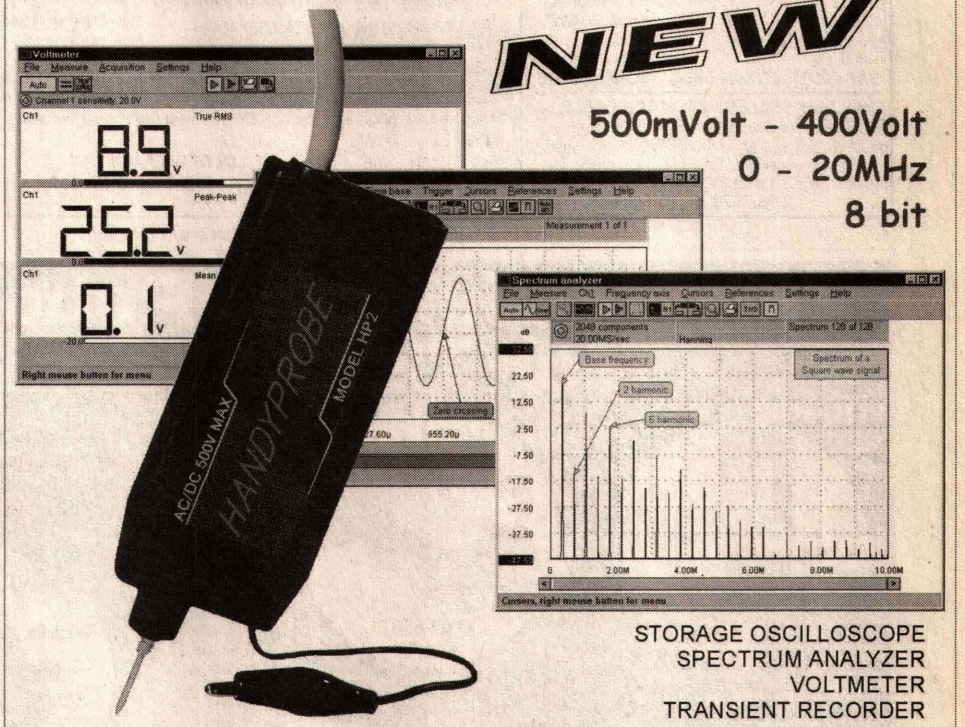

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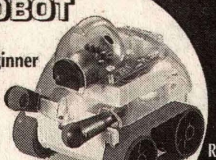

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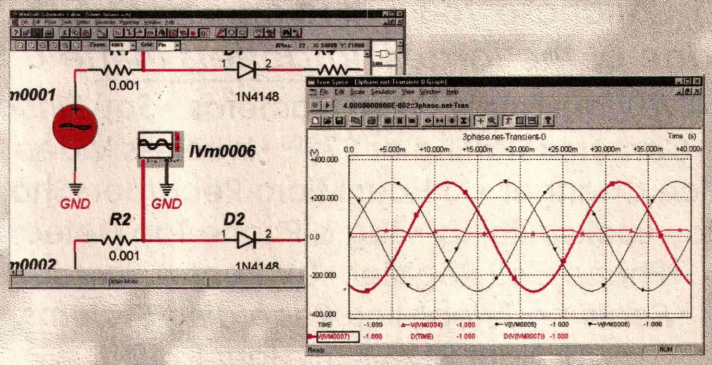

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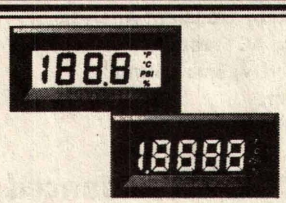

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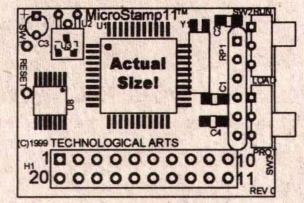

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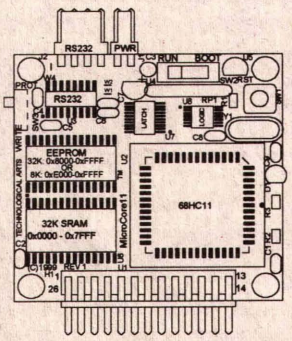

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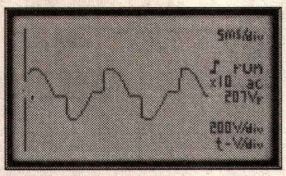
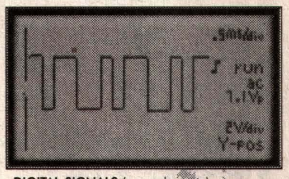
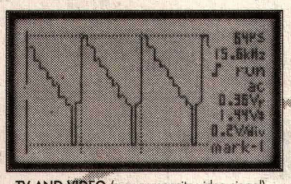


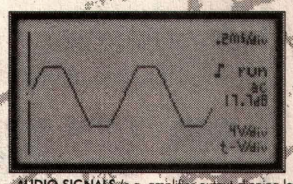
AC MAINS (e.g. phase control)



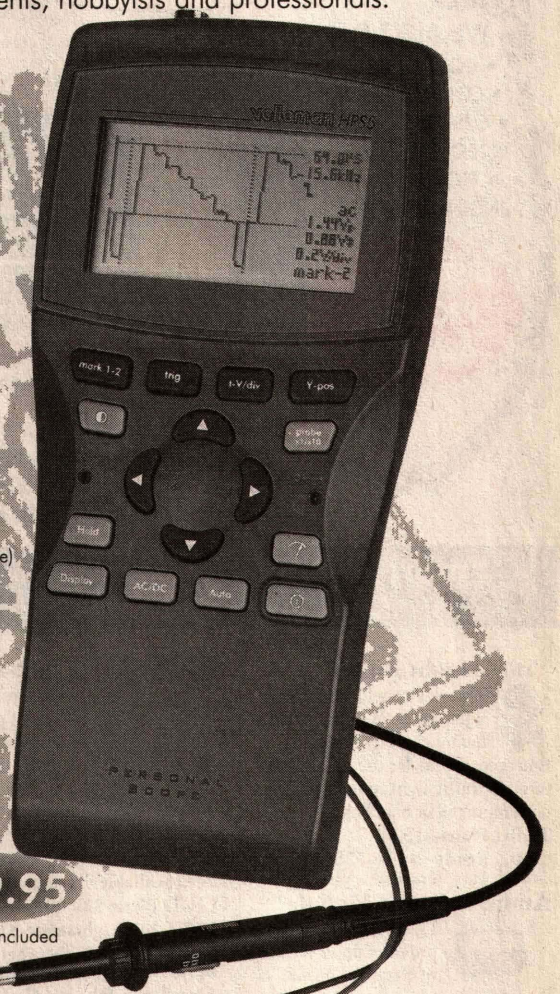
DIGITAL SIGNALS (e.g. pulse train)



TV AND VIDEO (e.g. composite video signal)



AUDIO SIGNALS (e.g. amplifier output clipping level)



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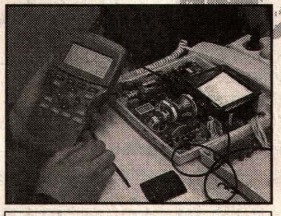

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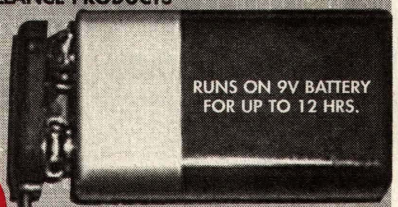

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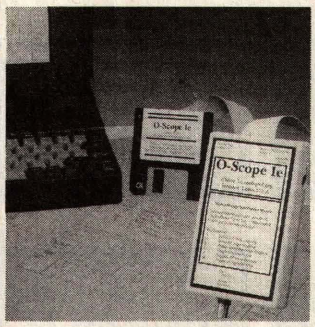

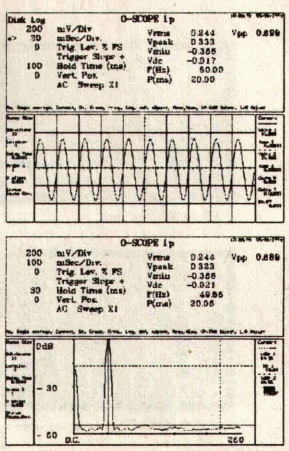

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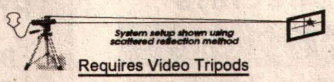

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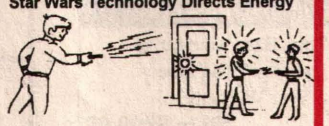

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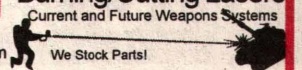

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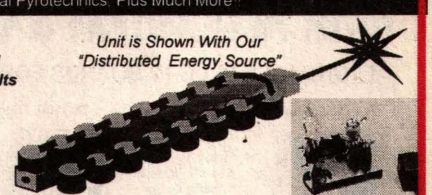

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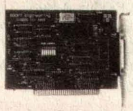

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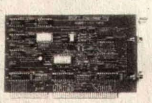

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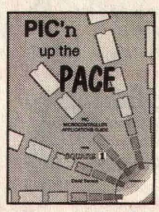

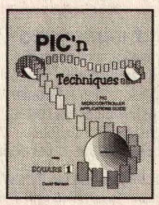

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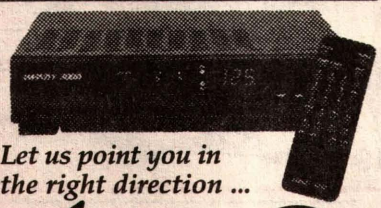

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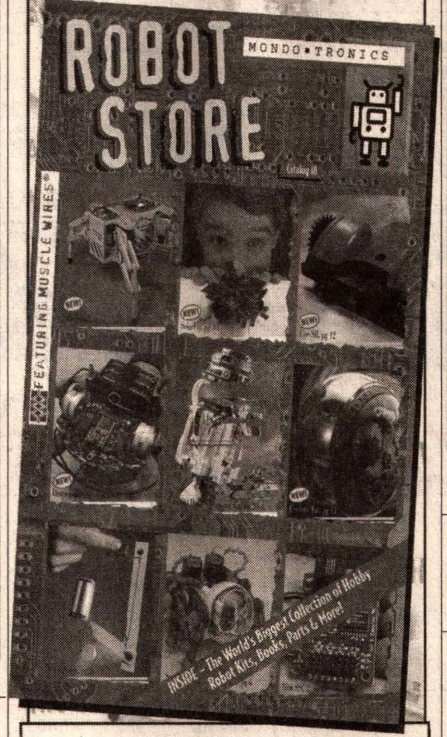
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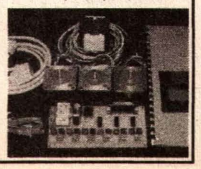

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Model SPL-603 3A 0-30VDC

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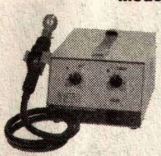
Elenco Hot Air SMD Rework Station
Model SR-979



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Weller Soldering Station
Model WES50

50 watts of controlled power - designed for continuous production soldering.

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Weller Low Cost Soldering Iron
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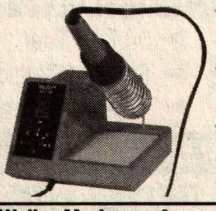

- Variable power control produces 5-40 watts.
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Weller Marksman® 23W Soldering Iron **Model SP23**

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Elenco Model F-1300

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- Math Functions
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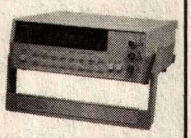

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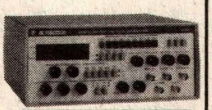

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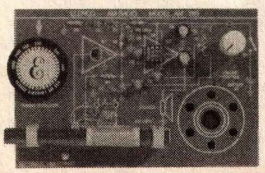

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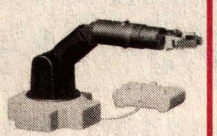

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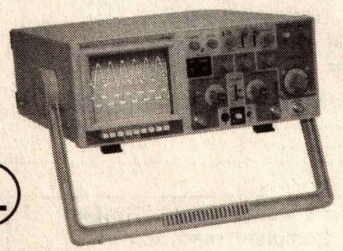

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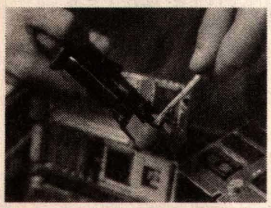

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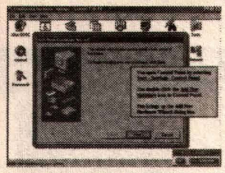

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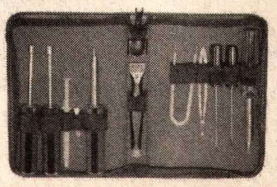

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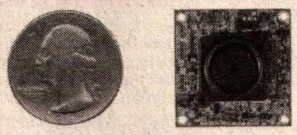

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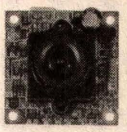

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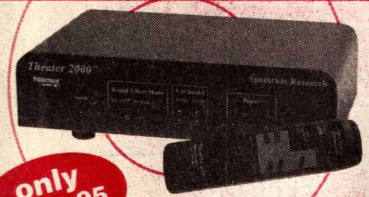

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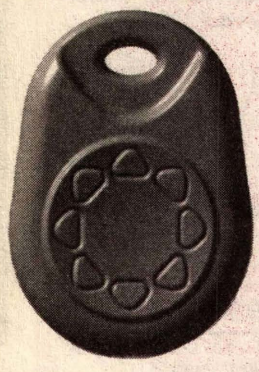

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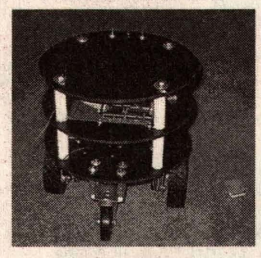

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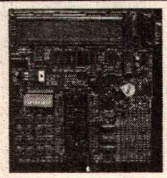

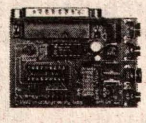

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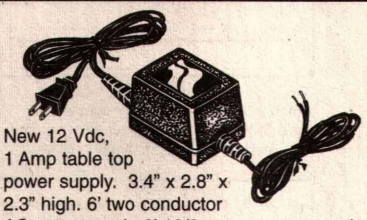

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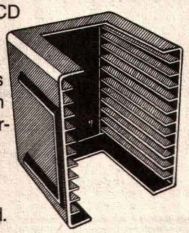

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Resettable Circuit Protector 0.65 - 1.3 Amp

Raychem "Polyswitch" # RXE-065S-1 General purpose circuit protectors for power supplies, alarm systems, speakers, motors etc. Unlike traditional fuses, they automatically reset when fault condition is cleared. Can be paralleled for higher ratings. Current: 0.65 Amps. Trip Current: 1.3 Amps. Max Voltage: 60 Volts. 0.33" diameter. UL, CSA listed.

CAT# RXE-065

100 for $20.00
500 for $85.00
1000 for $150.00

3 for $1.00

"Ear Bud" Stereo Earphones

Miniature "in-ear" earphones for use with most portable CD, radio and tape players. 3.5 mm stereo phone plug. 32 ohm impedance. *Large Quantity Available*

CAT # HP-6

10 for $7.50
100 for $50.00

85¢ each

22 UF 450 Vdc

0.63" diameter X 1.6" long axial electrolytic capacitor.

CAT# 22/450VA

$1.25 each

10 for $10.00
100 for $80.00

Powerful 12 Vdc Motor

Bosch. Powerful new 12 Vdc motor with replaceable brushes. Purchased from a company making electric bicycles, they were used two per bicycle, powered with a 24 Volt battery pack. May have originally been fan motors for Ford automobiles. 4" diameter x 2.75". 0.31" (5/16") diameter shaft is 1.2" long. No load Rating: 2200 RPM @ 12 Vdc @ 2.8 Amps. Weight: 3.25 lbs. 0.25" quick-connect terminals.

CAT # DCM-142

$9.50 each

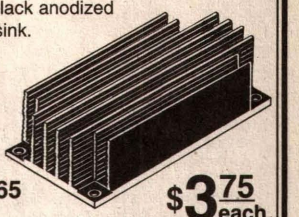
16 Character X 2 Line LCD with Backlight

Daewoo # 16216L-5-VSO 5 x 7 dot format. 2.56" x 0.54" viewing area. 3.15" x 1.41" module size. LED backlight. Includes hook-up/spec sheet.

CAT# LCD-53

$7.50 each

Heatsink



4.53" X 2.3" X 1.44". High-capacity black anodized aluminum heatsink. Serrated fins. Mounting holes on 4.2" x 2" centers. Weight: 0.54 lbs.

CAT # HS-65

$3.75 each

MINI-RIGHT ANGLE GEARHEAD MOTOR WITH CIRCUIT CONTROL

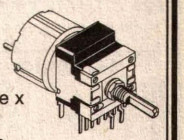
Omron # R2DG-41 Built-in control circuits allow this motor to be used in a continuous or a pulsed mode. In continuous mode the final drive gear turns at 22-45 RPM (3-6 Vdc). In the pulsed mode the final drive gear turns one revolution each time the controller is momentarily pulsed. The motor assembly is 1.75" x 1.25" x 0.5" overall. The nylon final gear is 0.62 diameter and has a little nipple slightly off-center to which a small push-rod could be attached. Motors are in good condition, removed from equipment. Hook-up instructions included.

CAT# DCM-110

10 for $60.00

$7.50 each

Motorized Potentiometer Dual 10K Linear Taper



Alps Electric # 726T-10KBX2 Dual 10K linear pot powered by a small reversible 6 Vdc gearhead motor. Pot and motor assembly are 1" square x 1.7" long excluding shaft and bushing. 6 mm flatted shaft is 0.5" long. 9mm threaded bushing. PC pins and mounting tabs for pc board mounting.

CAT # MPOT-10K

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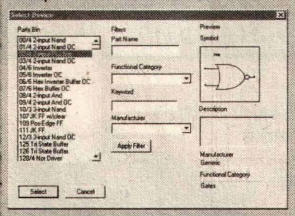

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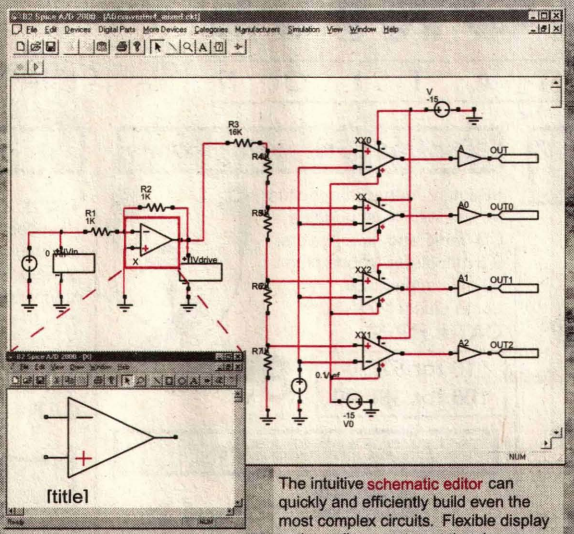

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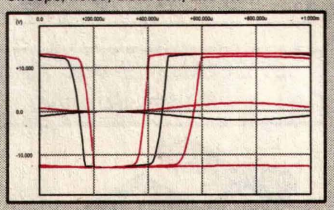

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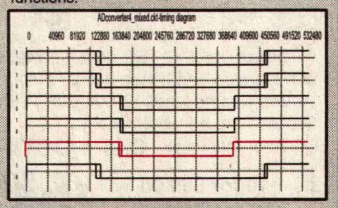

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6" VGA LCD 640X480, Sanyo LMDK55-22 **$19.00**

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Hacker Corner

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Unit has a backup Ni-Cd battery system in case of power failure (5 min. backup time) and lockable front cover to prevent floppy drive access. Mounting / interface provisions for standard 3.5" laptop floppy and 2.5 inch hard drives. Comes with very comprehensive manual.

SONY Miniature Color LCD Display $29.00

1.8cm (0.7 inch) unit LCX009AKB 827H x 228V **$29.00**

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These transceivers were designed for operation in an AMPS (Advanced Mobile Phone Service) cell site. The 20 MHz bandwidth of the transceiver allows it to operate on all 666 channels allocated. The transmit channels are 870.030-889.980 MHz with the receive channels 45 HMz below those frequencies. A digital synthesizer is utilized to generate the selected frequency. Each unit contains two independent receivers to demodulate voice and data with a Receive Signal Strength Indicator (RSSI) circuit to select the one with the best signal strength. The transmitter provides a 1.5 watt modulated signal to drive an external power amplifier. channel selection is accomplished with a 10 bit binary input via a connector on the back panel. Other interface requirements for operation are 26 VDC (unregulated) and an 18.990 MHz reference frequency for the digital synthesizer. The units contain independent boards for receivers, exciter, synthesizer, tunable front end, and interface assembly (which includes power supplies and voltage-controlled oscillator). Service manual, schematics and circuit descriptions included.

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Compact (4.4" x 3.8" x 1.4") TFT active matrix LCD color monitor including fluorescent backlight. Analog RGB and composite sync input with switchable horizontal / vertical viewing. Low power consumption and long life backlight make it ideal for security and door phone use. Single 8 VDC supply and good resolution allow mobile operations or use with laptops. Standard ribbon cable - Molex connector interface. Complete specifications included.

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HANDY ANYWHERE LIGHT

NEW!

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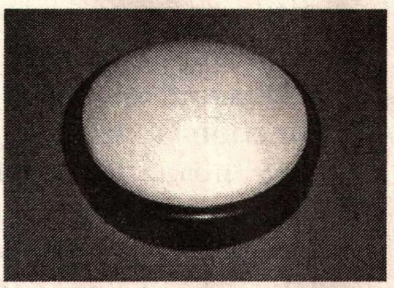
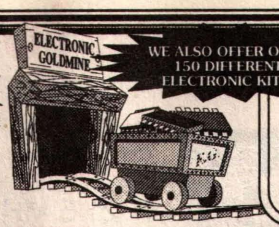


G1805 $4.98



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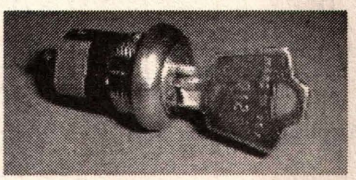

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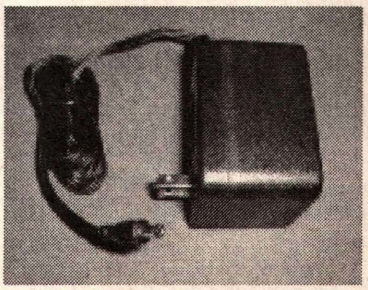
G1813 $34.95

13VDC 2 AMP COMPACT ADAPTER

This is one of the most powerful adapters for its size that we have ever seen. Designed for plugging into standard 120VAC with an output of 13VDC 2000ma,. Features black case only 3 1/4"L x 2 1/2"W x 2 1/8" thick. Has flexible cord with 5.5mm female barrel jack and 2.1mm center (+). Brand new UL and CSA approved



G1780 $7.95

JAMICON ULTRA THIN 12VDC MICRO FAN

Designed for cooling microprocessors these 1 1/2" square fans are only slightly thicker than 3/8" thick. Operates on 12VDC at .17amp. With flexible color coded leads.

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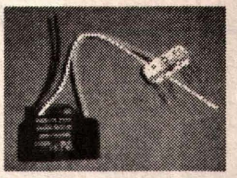

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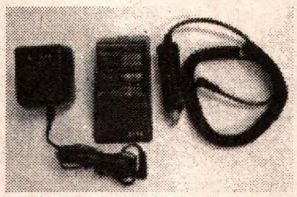

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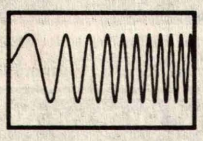
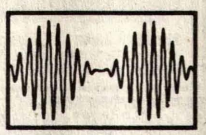
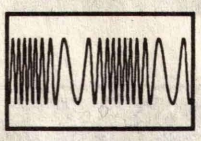


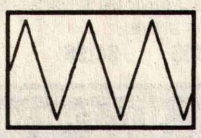
DC to 21.5 MHz linear and log sweeps



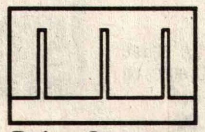
Int/Ext AM, SSB, Dualtone Gen.



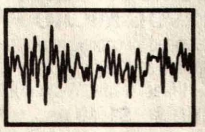
Int/Ext FM, PM, BPSK, Burst



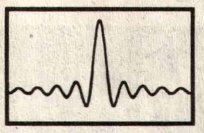
Ramps, Triangles, Exponentials



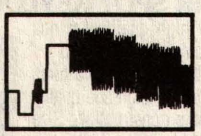
Pulse Generator



Noise



Arbitrary Waveforms



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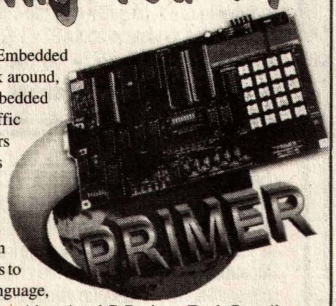

Are you interested in Microprocessors & Embedded Control Systems? If not you should be! Look around, just about everything these days has an embedded microprocessor in it. TVs, cars, radios, traffic lights & even toys have embedded computers controlling their actions. The Primer Trainer is the tool that can not only teach you how these devices operate but give you the opportunity to program these types of systems yourself. Examples & exercises in the Self Instruction manual take you from writing simple programs to controlling motors. Start out in Machine language, then move on to Assembler, & then continue on with optional C, Basic, or Forth Compilers. So don't be left behind; this is information you need to know!

Examples Include:

- **Measuring Temperature**
- **Using a Photocell to Detect Light Levels**
- **Making a Waveform Generator**
- **Constructing a Capacitance Meter**
- **Motor Speed Control Using Back EMF**
- **Interfacing and Controlling Stepper Motors**
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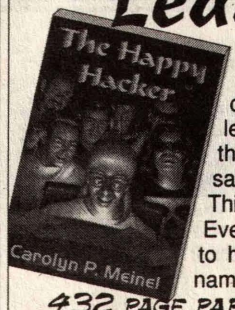

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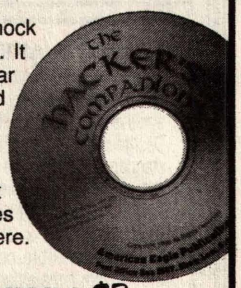

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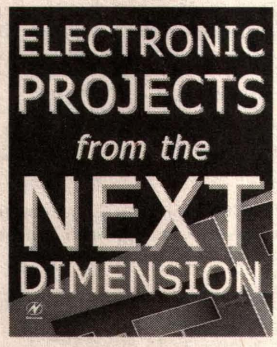

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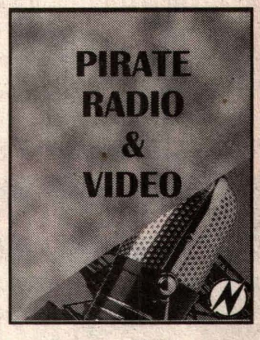

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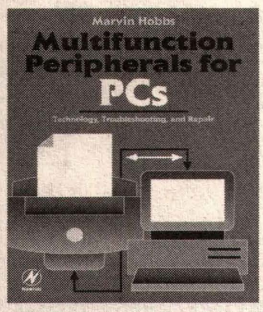

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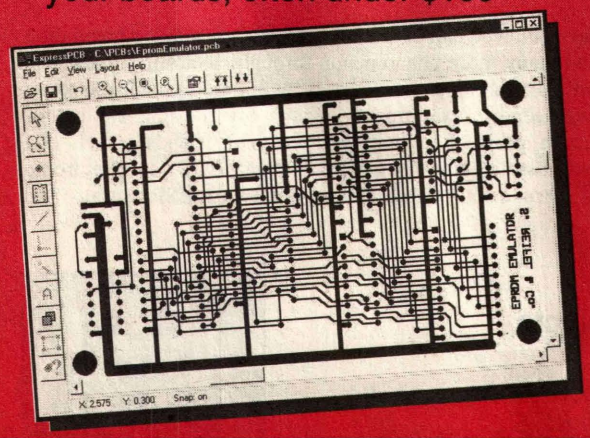

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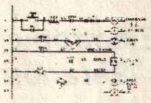

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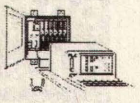

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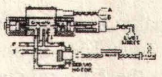

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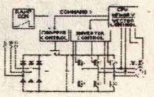

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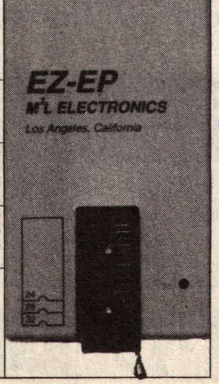

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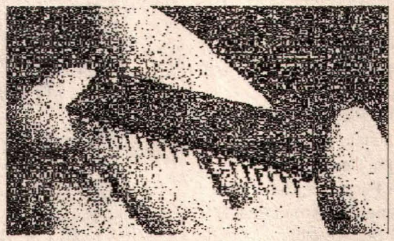

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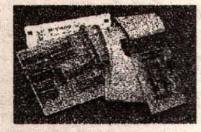

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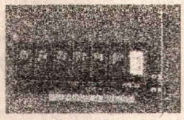

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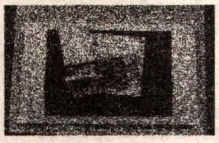

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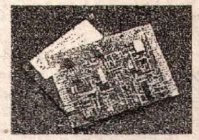

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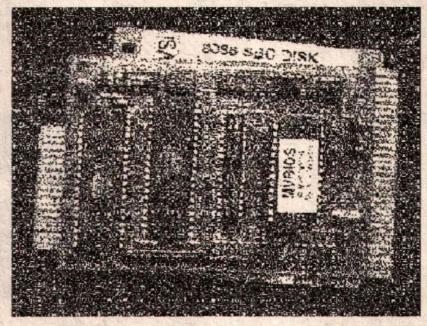

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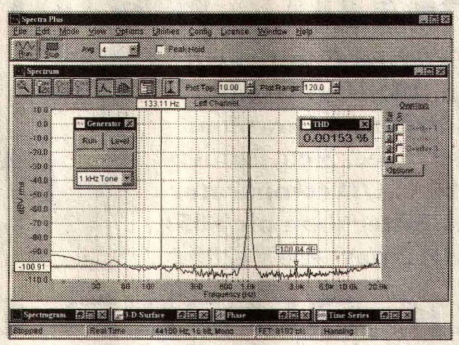

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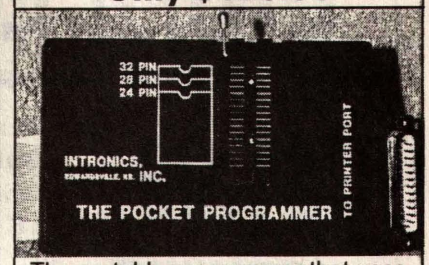

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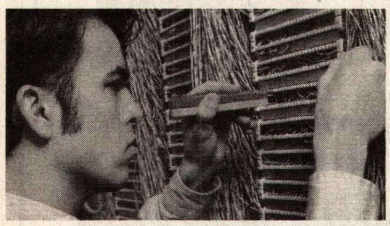

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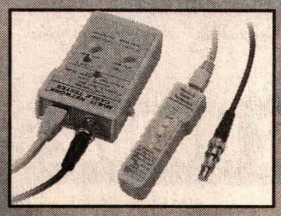

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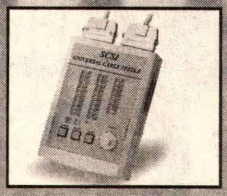

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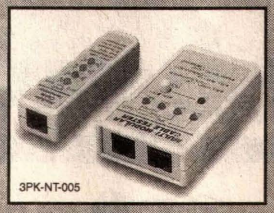

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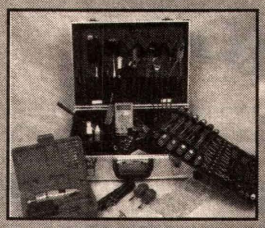

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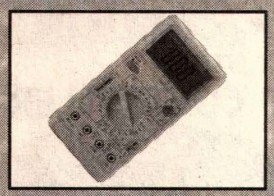

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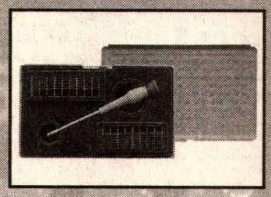

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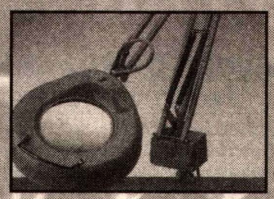

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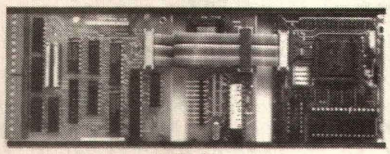

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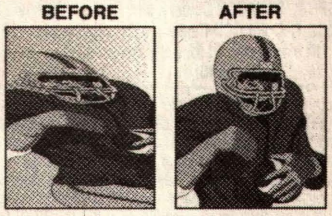

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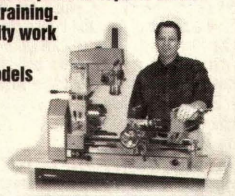

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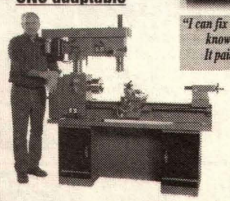

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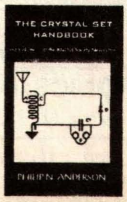

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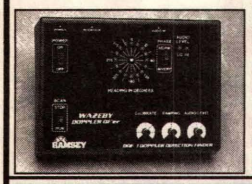

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DDF-1, Doppler Direction Finder Kit $149.95

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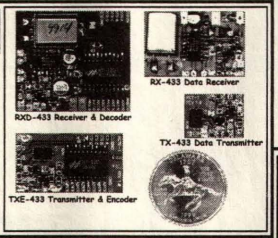

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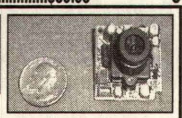

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AM-25, Professional AM Transmitter Kit. $129.95
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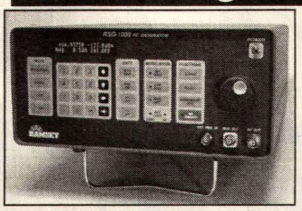

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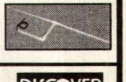
FM Station Antennas



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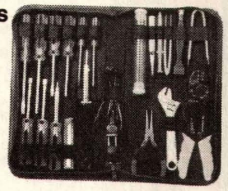

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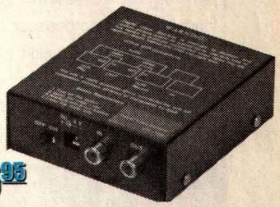

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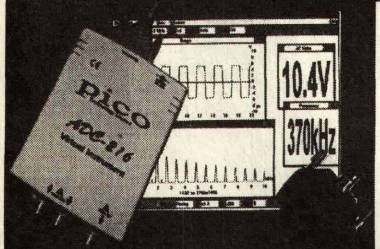

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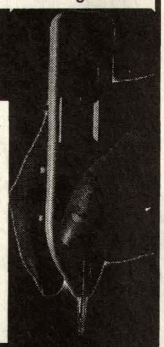

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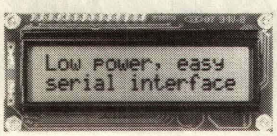

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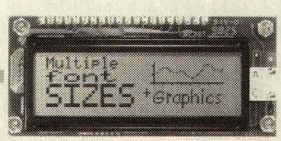

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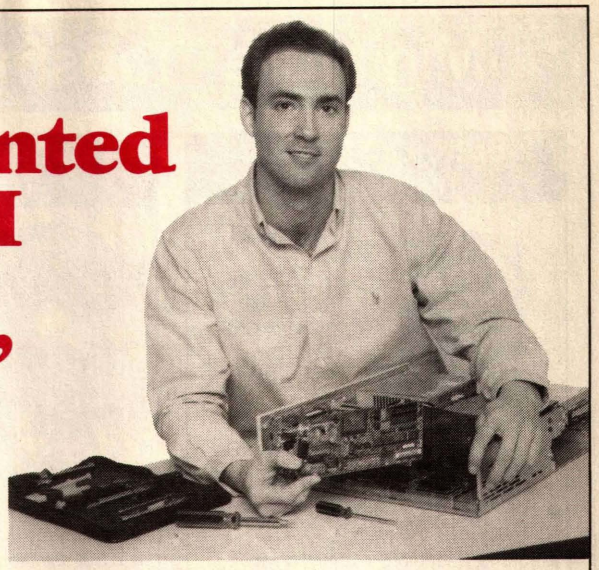

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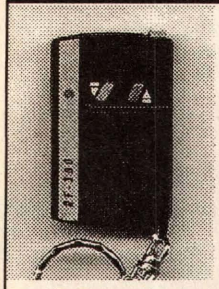

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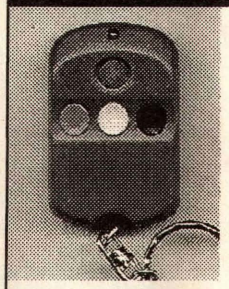

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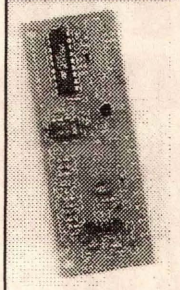

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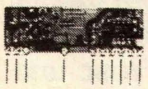

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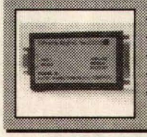

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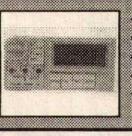

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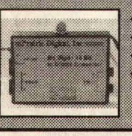

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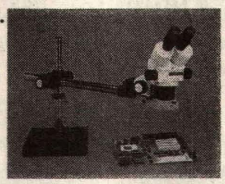

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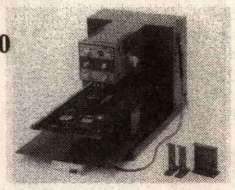

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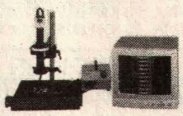

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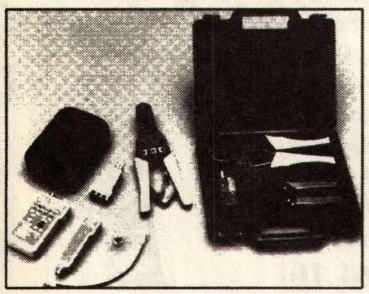

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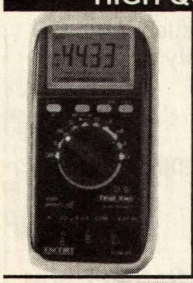

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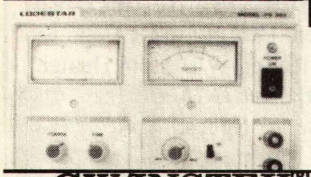

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	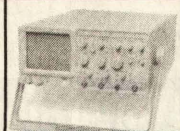		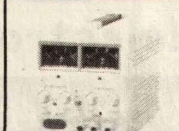		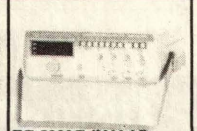	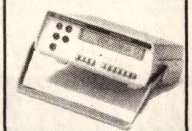
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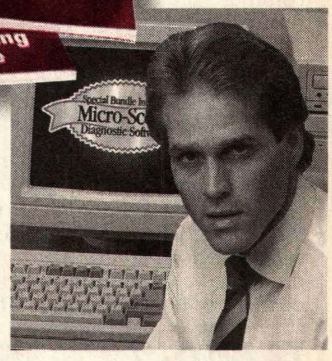

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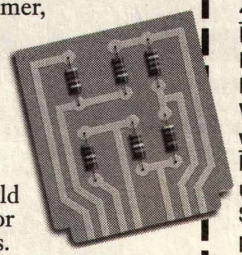

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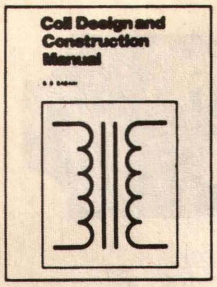

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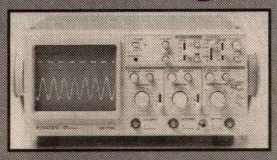

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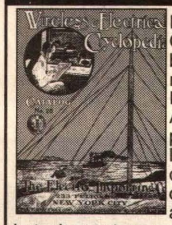

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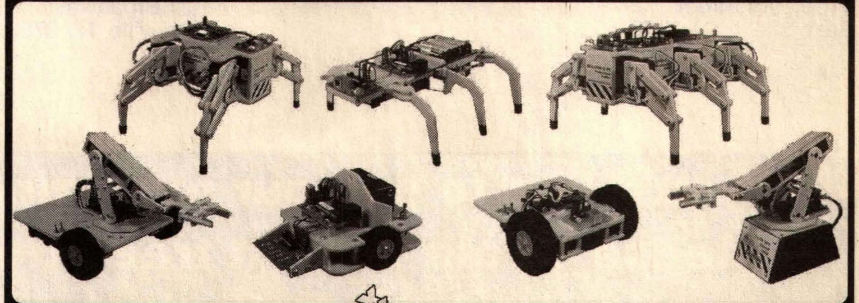

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ProService Review

May, 2000

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PURPOSE

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FCC Prods Consumer Electronics Industry on Compatibility Issues

The promising future of Interactive TV has been stalled too long by the inaction of vested interests. It's time to move IPTV from the vast wasteland to the vast wonderland.

by William E. Kennard, Chairman, Fed. Communications Commission

Editor's Note: *The following is edited from a speech prepared for delivery by Mr. Kennard to the participants at the 2000 International Consumer Electronics Show, January 7, 2000.*

In the old world, services like television, and cable, and telephone constituted different ways of delivering different products. The conduit defined the content. But these rules have been rewritten by digitization.

Conduit no longer defines content; the lines of competition and regulation have been blurred, and new consumer electronics devices are blended versions of the old. But in one area digital technology has yet to fully take hold: television.

Televisions are almost all still analog. Where broadcast digital TV is available, it is not yet carried on cable. And if you buy a digital TV, it probably won't work with your cable TV.

To watch cable, you would have to watch it on your old set, or employ a converter that dissipates much of the resolution advantage of digital transmission. That's a little like riding on a train and having to move from first class to coach class at the border.

THE DIGITAL DREAM: IPTV

For years, visionaries have predicted that the future of television was, in fact, not really television at all, at least not the television we have all been used to. Rather, it's something more like the computer.

The vision has been of two-way, interactive TV that has the digital agility of the computer, but the display quality of a movie theater that can be summoned on-demand.

A single device would be a multimedia source of news, information, and entertainment. It would marry the various platforms, whether cable, broadcasting, satellite or the Internet, n a way that allows them to coordinate and compete at the same time.

And it would offer the viewer program choices that take us from what one of my predecessors called the vast wasteland of television to a vast wonderland of limitless content. From our couch potato past to the interactive future. The viewer actively engages the programming. The viewer can replay portions of TV shows as they are being aired, summon sports scores and web sites instantly, or download movies in a snap.

It's a world in which time shifting is the rule, not the exception.

We have a name for this future: IPTV. Like digital TV itself, IPTV can be many things. IPTC can mean "Interactive Personal TV," because it allows viewers to personalize the programming to their own particular needs.

It can mean "Intelligent Personal TV," because it is a "smart TV," and has much of the intelligence formerly in the network now in the television set.

And IPTV can mean "Internet Protocol TV," because it can serve as an on-ramp to the Internet.

At the January Consumer Electronics Show, dealers saw wonderful glimpses of the future of television, and it is all about IPTV.

But IPTV has yet to become a part of the American household. Why is this? It is not because of a lack of consumer demand.

(continued on PS-2)

Calendar of Events

CEA Technical Workshop: Monitor/TV Servicing
April 10-12, 2000
Arlington, VA
Contact: Sharon Means 703-907-7599
www.ce.org

CEA Technical Workshop: PCs/Peer-to-Peer Networking
May 15-17, 2000
Arlington, VA
Contact: Sharon Means 703-907-7599
www.ce.org

CEA Technical Workshop: DVD Servicing
June 7-8, 2000
Arlington, VA
Contact: Sharon Means 703-907-7599
www.ce.org

Digital Hollywood - Tools, Technology, R&D
June 7-10, 2000
San Jose CA
CEA (VA): 703-907-7600;
www.ce.org

CEO Summit
June 21-23, 2000
San Diego, CA

COMDEX Canada 2000
July 12-14, 2000
Metro Toronto Convention Centre
Toronto, Ontario CANADA
Steve Prahalis 416-283-3334, ext. 1581, or in U.S. 781-433-1581;
steve_prahalis@zd.com
www.zdevents.com/exhibitors

NESDA's 50th/ISCET's 30th Annual National Professional Service Convention & Professional Service Trade Show
August 6-12, 2000
John Ascuaga's Nugget Hotel
Sparks (Reno) NV
Clyde Nabors (TX): 817-921-9061, ext. 10
clydenesda@aol.com; www.nesda.com

CEA Technical Workshop: Monitor/TV Servicing
August 14-16, 2000
Arlington, VA
Contact: Sharon Means 703-907-7599
www.ce.org

Nebraska Electronic Service Association's Fall Convention
September 8-10, 2000
Holiday Inn@ Grand Island Exit (Hwy. 80)
Jon Ludwig (NE) 402-464-9181 or
Myron Sahs (NE) 402-291-0559

CEA Technical Workshop: PCs/Peer-to-Peer Networking
October 11-13, 2000
Arlington, VA
Contact: Sharon Means 703-907-7599
www.ce.org

AFSM International's 30th World Conference & Exposition
October 15-17, 2000
The Opryland Hotel Convention Center
Opryland USA, Nashville, TN
Contact: Ginny Goodman 914-275-7887;
Fax 914.275.0794; ggoodman@afsmi.org
www.afsmi.org

CEA Fall Conference
October 15-18, 2000
San Francisco, CA
703-907-7600; www.ce.org

CEA Technical Workshop: DVD Servicing
November 15-16, 2000
Arlington, VA
Contact: Sharon Means 703-907-7599
www.ce.org

2001 International CES - Your Source for Workstyle and Lifestyle Technology
January 7-10, 2001
Las Vegas, NV
www.cesweb.org

(FCC Warning, continued)

Studies, focus groups, people on the street will tell you that they want the features that fully capable digital television could offer. That is high-quality programming and the ability to interact with that programming.

It is not because the government has blocked the rollout of IPTV.

Congress and the FCC have made a big push to launch the digital revolution. Congress shifted spectrum to broadcasters for digital transmissions, and the FCC implemented policies to stimulate high-speed Internet access through cable and copper.

Some broadcasters have responded, and now more than 100 stations reaching 50% of the American people offer high quality digital TV signals. Dealers have received delivery of about 111,000 digital TVs since August of 1998.

Cable modems are now in nearly 1.5 million households, and an estimated 4.1 million households subscribe to digital cable, and it is available to millions more. Almost 500,000 households access the Internet using high-speed DSL connections. And there are almost 11 million digital satellite households.

So what's the problem? Why aren't more Americans able to enjoy IPTV?

The problem is that those in the cable and consumer electronics and programming industries — those involved in making fully capable digital TV a reality — cannot reach agreement in two key areas: (1) they have not been able to agree on standards that allow the various delivery platforms and enhancements to work together; and (2) they have not been able to agree on copyright protection that will unleash the quality programming for the interactive future.

The industries have made great strides toward closing the gap on the first problem, on compatibility standards. Ninety percent of the problems appear to be solved. But how do we close that last 10%?

That's the dilemma. There's general agreement on the end game, on the general notion of IPTV, but getting there is the rub.

MAKING IPTV A REALITY FOR AMERICAN CONSUMERS

Here are the three elements of the dilemma:

First, the economic and technological barriers to rolling out IPTV are so numerous that the market has had a tough time crafting a solution. There are so many industries involved, each with their own competing architectures and incentives, that finding common ground has been extremely difficult.

This situation contrasts dramatically with the way color TV rolled out in the early 1950s. Things were a lot simpler then. At that time, one firm, RCA, was involved in every aspect of the system, from start to finish. RCA manufactured TVs and transmitters, and it owned a leading TV network, NBC. It had the incentive and the ability to lead the conversion to color, and whether measured by color television sets sold or color programming transmitted, RCA led the way.

In the case of IPTV it is much more complicated. There are multiple players and competing incentives. Broadcasters, for example, want cable-ready television sets, because cable carriage will allow broadcasters to capture more market share for their advertisers.

Cable operators, however, are hesitant to transfer too much of their network intelligence to the viewer's television. They worry about losing control of the viewer, because, for example, the viewer might use someone else's program guide.

Manufacturers want to sell equipment that works and that consumers can afford.

My concern must lie, first and foremost, with the interests of the consumer. And so the challenge is to harness the divergent industry interests in a way that best serves the consumer.

Second, it is the nature of open markets that if a bottleneck appears in one part of the market, the market will find a way around that bottleneck in another part of the market. Those waiting in line at the bottleneck will be left behind.

This may be happening already. While you have been negotiating standards, the marketplace is moving on. Services like "iCrave TV" and the European service "Chello" are developing internet-based TVD distribution that threatens the market share of traditional media. And "Broadcast.com" is streaming video, although not yet in broadcast quality.

I know many in the American consumer electronics industry may be troubled by these developments, but the best way to respond is to resolve these compatibility problems that I mentioned before. Break down the bottleneck that is preventing consumers from getting IPTV.

Third, where the market does not work to promote consumer welfare, the Federal Communications Commission must. It's in the law. And, the public rightfully relies on the FCC when the market does not protect the public's interests.

To date, the Commission has exercised restraint on this matter, preferring to have the industry participants resolve the problems. But this "hands-off" phase is about to end. The various industry segments must bring closure to years of negotiations, or the Commission has to act.

As early as 1994, the VCC began pushing your industry to set standards for making digital televisions compatible with cable. At that time, industry representatives said they would have standards by 1995, so the Commission declined to act.

In August of 1998, we again asked for resolution of the compatibility problems, in particular for agreement on a 1394 connector standard. In October, 1998, industry groups said there would be cable-ready, content-protected retail sets available by November, 1999. The issues were not resolved, and a a timetable was requested by July 1, 1999.

On July 1, I received assurances that the copy protection problem would be solved by August 1, and that the compatibility specifications would be available by November 1.

In December, we still weren't there yet, so I asked the Commission's top engineer, Dale Hatfield, to convene a group from NCTA, CEA, OpenCable and others to identify the last remaining issues and to resolve them.

And now here we are, in the year 2000, six years after industry first asked the Commission to refrain from acting, and there is no resolution. In Internet time, 1994 is the prehistoric age, because there was not even a commercial Internet then. And yet six years later, we have still not resolved the compatibility issues. Why not?

Here are two important compatibility sticking points: (1) in addition to certain technical details, your industry and the cable industry differ over the definition of "cable ready" digital television, in particular, over whether every cable ready set must have a 1394 connector; and (2) you also differ on how program tuning and scheduling information will be made available to consumer electronics devices. This is an issue that bears directly on the range of choice consumers will have in electronic programming guides.

The Commission's rules require that, as of July 1, 2000, consumers must be able to purchase set top boxes on the retail market. I was pleased to hear from Cable Labs that we appear to be on track to meet that deadline.

Copy protection is another major sticking point. Consumers will not purchase high-priced digital TV sets if there is not high-quality digital programming available. Just look at the explosion of DVD sales now that Hollywood is making product available for that market.

I appreciate the need for content owners to protect their product in the digital world. But this problem has to be solved. And it can be solved.

Here too, the Commission has encouraged negotiations between content providers and distributors and CE manufacturers. 5C appears to be the most promising copy protection technology. But there remain significant licensing and implementation issues.

Then there are the naysayers. Parties who say there can by no viable copy protection solution. They say that if programming is made available, there will be theft, and that therefore the options are either theft or no programming at all.

But I reject this all-or-nothing approach. Through the creative use of technology, we can do both: get good programming to the public and protect the rights of its creators.

Consumers can have choice without theft. The technology can be used, for example, to limit use of the programming to one copy, or one viewing, or multiple copies and viewings for a price. This was the concept behind Divix, even though that particular solution was not accepted by the marketplace. But the technology that presents the problem also offers the promise of a solution. We must not let the naysayers stop progress toward a solution.

Finally, with regard to programming, too many broadcasters have just not realized the potential of IPTV. Many see it simply as high-definition television — prettier pictures that alone will not provide the returns to justify new investment in digital TV. IPTV, with its interactive capabilities, however, offers much more.

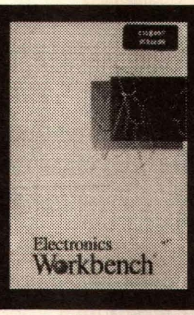
To make IPTV a reality, broadcasters will have to develop new business models, and forge new ground.

I frankly do not know which problem is the prime obstacle here — equipment compatibility, or copy protection — but frankly, consumers don't care. They just want the problem solved.

And we owe it to them to solve it. I have an obligation to solve it.

Consequently, I have directed the FCC staff to draft a set of proposed rules for digital TV compatibility standards. So, if you — manufacturers, broadcasters, cable owners, and software providers — cannot solve these problems by April of this year, the FCC will move to protect the public interest.

Once again, I am laying down the challenge. Let's get these compatibility issues behind us. Let's solve the copy protection problem. Let's fulfill the digital promise for the American consumer. Let's make IPTV a reality. §



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— Technology —

Digital Technology Fuels Changes for the Next Century

From the days of the wireless telegraph, the consumer electronics industry has made some drastic changes in its direction. But which way will technology head in the near future?

by Gary Shapiro, President, Consumer Electronics Association

Editor's Note: *The following is edited from a speech prepared for delivery by Mr. Shapiro to the participants of the 2000 International Consumer Electronics Show, January 5, 2000.*

By every measure, this is a special and extraordinary time. It is a time that finds us using new and unfamiliar numbers to describe the past year. It is also a time which finds our products and our industry front and center of a technology revolution which is changing the world and the lives of its citizens.

Looking back over the last 100 years, the buzz at the beginning of the century was about simple wireless telegraph and the Victrola. Since then, the consumer electronics industry has evolved from a hardware business to a consumer technology industry that combines hardware, content and services.

Digital technologies will continue to be the driving force of this change. Sales of digital products hit the $30 billion mark in 1999, and we expect sales to reach $38 billion in 2000. Those are extraordinary numbers. Delivering digital music, video, data and voice communications offers huge opportunities for all of us.

Right now, the digital revolution is being led by DVD and home satellite. Both categories had record years in 1999 with DVD sales increasing by 300 percent. The recent passage of the CEA-supported Satellite Home Viewer Act will further boost sales as it allows consumers to receive local channels. This creates a true alternative to cable.

Digital television is also poised for explosive growth. Though still in its infancy, we closed out the year on target with sales reaching 100,000 units just as we projected a year ago. By the end of this year, we expect the industry to sell 600,000 DTVs. That is an achievable goal — provided there is greater availability of programming. Content has always driven the growth of new consumer technologies. I urge broadcasters and cable providers to focus on providing DTV content.

We are confident that all the industries will soon come together and finalize the OpenCable specification and resolve the copy protection issue. These have been major hurdles for all parties and we must overcome them quickly.

Let us not forget digital audio, which started the digital revolution more than 10 years ago. New technologies are taking digital audio to new heights — and depths — of audio enjoyment. The first-ever digital radio pavilion at the 2000 Consumer Electronics Show is a part of the story. Another is the MP3 craze which has renewed excitement in audio, especially among GenXers. As long as intellectual property issues do not create an inconvenience for consumers, this category will explode.

But, the biggest change now taking place is the Internet. Research indicates that by the end of 2001, 25 percent of A/V sales could be done online, if the products were available. The question we must ask ourselves is, if consumers can't find our products online, will they buy something else there instead? Can we take that risk?

Many believe that click-and-mortar retailers — those who have both a storefront and Internet presence — will come out ahead. Surveys show that many consumers like to research their purchases on the Web, but want to buy in a store. It is too early to predict who will be the winner. But one thing is certain, if you haven't yet examined your e-commerce strategy, now is the time, before it is too late.

So what about our future?

In the next five years, our newly focused industry will generate more products in more configurations and combinations than in the entire history of the consumer electronics business.

Content will be delivered to consumers by an incredible array of boxes; today it is personal video recorders. CD players, computers and Web boxes. We will see an increasing selection of boxes — but also integrated products and home networks. Information and entertainment will be stored on a home server, accessible from any room or anywhere.

Wireless will be a huge category as today's PDAs and wireless phones evolve into new multifunction devices with more capabilities and services like full motion video and remote Internet access.

Looking forward, our industry will help define the century. Here's why:

- We are essential. We bring access to information and entertainment to the world's citizens.
- We are ubiquitous. Go anywhere in the world and you will see our products. Satellite technology, cells, batteries, solar-power and biomechanical power will enable even broader access to our products.
- We are mobile. We provide anywhere, anytime access to information, entertainment and education without wires.
- We are defining the lifestyle and workstyle of the 21st century.

Already, we are making the world smaller and we are making the world better. In short, we are changing how and where people work and communicate, and even how they are educated and receive health care.

Our future is bright and it is limitless.§

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— Management —

Lower the Risk, Not the Price

Your customers make purchases based on value, price and risk. What is risk, and how does it affect the purchasing decisions made by consumers?

by Dave Kahle

"How can I sell when I'm not the lowest price?"

"How can I keep my service customers when a competitor is promoting lower rates?"

I wish I had a dollar for every time I was asked that question in a sales training session. These are certainly the most common questions I hear coming from professional sales and service dealers.

There are a variety of answers — too many for just one column. But, we can identify one of the most powerful ways to deal with this problem.

First, let's start with this premise: "Low price" is not the main reason people buy!

In every survey of buying motivations I've ever read, low price is never the primary motivation. Yes, it's important. And, when everything else is equal, it will be the deciding factor. But very rarely is everything else equal. And very few people in this world buy only on the basis of low price. How many of you are driving used Yugos? Or wearing a suit you bought at a garage sale? Or watching an 8-inch black & white TV?

You've got the picture. You don't always buy on the basis of low price, so why should you think that all your customers do?

The truth is, they don't. And here's a secret that almost nobody knows, including all those gurus telling you to sell "value." They don't always buy the best value. But, they can invariably be counted on to buy the lowest *risk.*

The biggest issue in the minds of your customers and prospects is not price, and it's not value. It's risk.

What is risk?

It is the potential cost to the individual customer if he/she makes a mistake. It's not just the money, although that is part of it. It is also the social, psychological and emotional cost that your customer will pay if your choice isn't the best one. The lower the risk of the decision, the more likely your customer will say "yes" to you — regardless of the price.

First, let's become comfortable with this concept of risk. Then we can discuss how to use it in your promotional efforts.

In order to really understand risk, you must first see this issue from your customers' perspective. Try to put yourself in their shoes, and calculate the amount of risk that *you* expect your customers to take when you offer them an opportunity to say "yes" to you.

Here's an illustration to help you understand this concept. Imagine that you're having friends over for a casual evening of dessert and drinks tonight. You are under orders by your spouse to pick up a package of disposable cups on the way home from work. You stop at the local grocery store, and make a selection between brand A and brand B. You pick brand A.

(continued on PS-6)

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(Price, continued)

After you bring the cups home, your spouse mixes up a pitcher of margaritas and pours one. The drink leaks out of the bottom of the cup and puddles on the counter. There is a hole in the bottom of the cup. You pour your drink into another cup and it leaks, too. In fact, every one of the cups you bought is defective.

What happens to you in this instant in time? What is the consequence of your decision? One of the painful consequences might be that your spouse is upset with you. But there are other costs.

You're going to have to fix the problem. If there's time, you'll have to run back to the store and replace the cups. So, in addition to the emotional cost, you must also pay in terms of extra time and additional money. All because of your bad decision. Those costs: negative emotions, time wasted, extra money spent; all combine to form the risk you accepted when you made your decision.

Here's a simple exercise to help you understand this concept. Draw a short vertical line. At the top of the line write the number 25. At the bottom, write the number zero. Now on a scale of 0-25, where would you put the risk of buying a package of disposable cups? You'd probably say it is close to zero. So, put an X on the line from 0 to 25 where you think the risk of buying those cups would be.

Let's look at an illustration at the other end of the scale. I once had an adoption agency as a client. When a young lady is in a crisis pregnancy, and she's making a decision as to whether or not to release her unborn child for adoption, how big a risk is that for her? Put your X on the line that represents your assessment of that risk.

Compare the X for the two different decisions, and you'll conclude that different decisions carry with them differing degrees of risk.

Now, let's apply this concept to your customers. Remember that every time you ask your prospects to say yes to you, they are accepting some risk. And each of those decisions you ask of them carries with it a different degree of risk.

Imagine your typical customer. Then think of the typical offer or decision you ask of that person. For example, take one of your newer products. Imagine you are presenting it to your customer for the first time. Or, suppose you're giving an estimate to repair a 2-year-old camcorder. Now, put yourself in his shoes and see the situation through his eyes. On the 0-25 scale, how much risk does your customer accept when he or she says "yes" to you?

For an easy way of calculating it, just ask yourself what happens to that individual if you, your company, or the product messes up.

If your customer buys that product and it doesn't do what you claim it will, what trouble will that make for your customer? If the camcorder goes bad again after six months — and just before an important event — how much frustration will your customer experience? What consequences will he or she pay? What is the risk?

And don't say that "there is no risk," because you'll take care of any problem that might develop. You may think that, but your customer doesn't *know* that. And remember, you're trying to see this from your customer's point of view, not yours. The amount of risk is what your customer perceives it to be.

Here's an example. Several years ago, a young man approached me to help his company with their sales efforts. They were selling a product that was, at the time, a real state-of-the-art breakthrough. The company designed computerized controls that were retrofitted on production equipment. As a result of the use of these controls, the savings in energy consumption would pay for the cost of the equipment in less than a year.

It looked like a great product, but he couldn't sell them as rapidly as the company wanted.

"Tell me how you go about selling them," I asked.

"We qualify our prospects to the point where we know we have someone who could use the equipment. Then I call the

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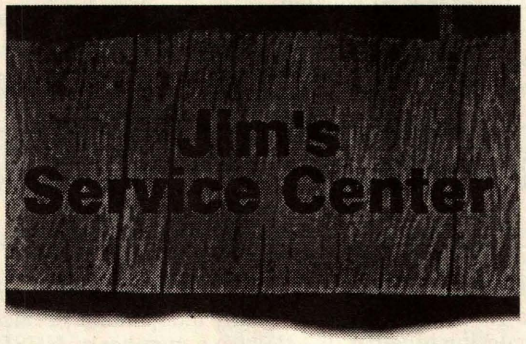

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production engineer or the plant manager on the phone, and gather some information about the type of equipment they use. Then I create a written proposal showing the economic payback, and mail it to him. Next I call and try to close the sale."

"Let me see if I understand correctly," I said. "You're calling a plant manager on the phone. I would guess that most plant managers are men in their 50s, probably with advanced degrees, and who have been in the plant for a number of years. Is that right?"

"That's right."

"OK," I said. "So, you're calling someone twice your age, asking him to spend $20,000-30,000 on equipment he's never seen, from a company he's never heard of, and from a sales person half his age who he's never met. Is that right?"

My client became a little defensive. "If you put it that way, I suppose it's right."

"Well, put it that way," I replied, "because that's the way he sees it."

The problem was simple: risk. On that scale of 0-25, how much risk would you think the plant manager would be accepting if he said "Yes" to the over-the-phone offer?

Put yourself in his shoes. Suppose the equipment didn't work the way it was supposed to? He could shut down production lines, spend weeks trying to make things right, cause all sorts of havoc in the plant, and potentially even lose his job. Now that's risk.

If you were that plant manager, how much more than the original $20,000 quote would you spend to reduce the risk? It wouldn't be hard to justify a price double that.

That should give you a clue as to how to fight the "low price" issue. Worry less about low price, and more about lowering the risk.

Here are four strategies to do so:

1. Build solid, deep relationships with the key decision-makers. Relationships mitigate risk. The greater the relationship, the lower the perceived risk. That's why the salesman with the longer relationship almost always has the benefit of the doubt in a competitive situation. It's not the price, it's the risk.
2. Make ample use of third party recommendations, customer lists, case studies and testimonials. All of these say to the customer that someone else, or lots of someone else's, have used the product or service. That means it's less risk for your customer to buy it.
3. Try to get your customer as physically involved with the product as possible. For example, if you're selling a piece of equipment, try to get the customer to trial the equipment, or at least visit somewhere it's being used. The more your customer can see and feel the actual thing, the less risk it is to him.

For the camcorder repair, calculate the odds of future breakdowns. Charge more for the service; enough to give the customer a full year — or even a two year — warranty. That way, you take the risk (at a proper reward), not your customer.

4. Finally, work with your company to create offers that reduce the risk by means of trial periods, money-back guarantees, delayed billing, warranties, service desks, etc. Whatever you do, gear your operations to reduce your customer's perception of risk.

The winners in the competitive selling — or servicing — arena of the Information Age are those who are the low risk providers, not the low price people.

About the Author: *Dave Kahle — known as the Growth Coach — is a consultant and speaker who specializes in helping distributors and their suppliers grow their sales and their people. Dave is the author of "How to Excel at Distributor Sales," and serves on the editorial advisory boards of two Simon & Schuster newsletters, "Strategic Sales Management" and "Professional Selling." He may be contacted at the DaCo Corporation, 15 Ionia SW, Suite 220; Grand Rapids, MI 49503; 800-331-1287; email: info@davekahle.com.* §

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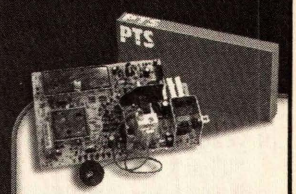

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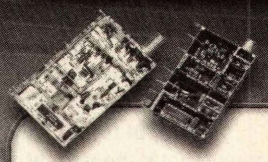

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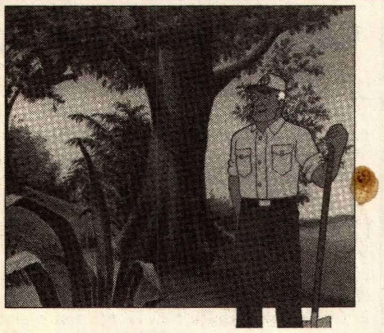

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PEAK COMPUTING

(continued from page 11)

after a program was closed.

Nevertheless, the most important upgrade the SE performs relates to future upgrades you will want to make. As this is our upgrade column, you can imagine this feature caught our eye. Put simply, Win98 SE has a more robust support for new peripherals and the IEEE-1394 interface. Just like Win98 made USB actually usable, SE does the same for the higher-speed, 1394 I/O system. Try installing a 1394 port board without SE and see if you can get it to work!

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NET WATCH

(continued from page 13)

genre-name-here" content-selectable station? First, you'll need to be using the latest version of Nullsoft's Winamp—that darling of a player we discussed last month. Then just visit the SHOUTcast site (you probably guessed the URL by now) and search for your favorite type of music. With a cable modem or other broadband connection, you'll be able to hear crystal-clear tunes. With a phone-line connection ... well, you'll want to switch to broadband as soon as possible. Listening to the stations ranked for low bit rates is a little too much like RealAudio. P

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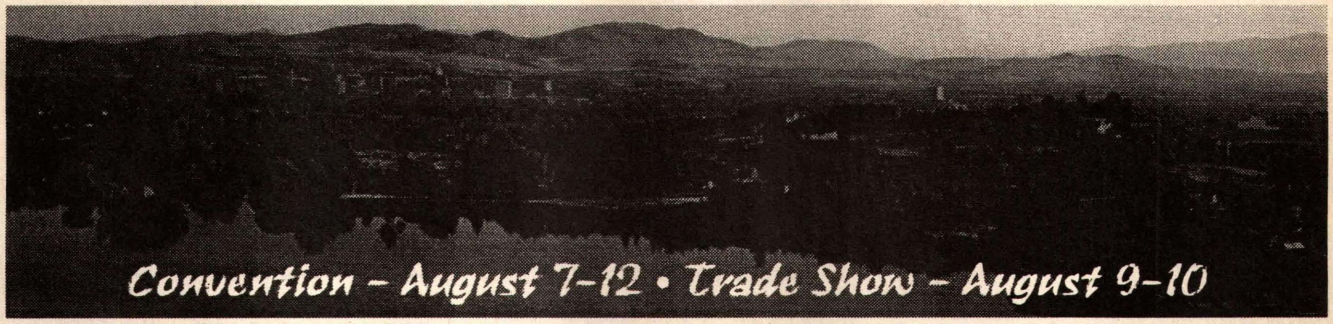

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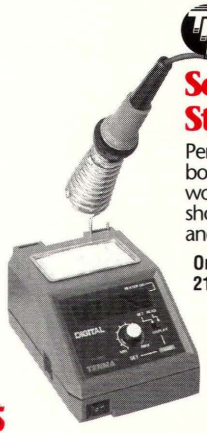

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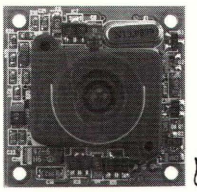

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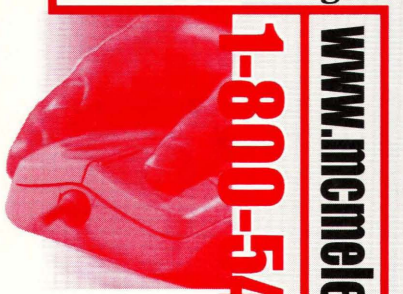

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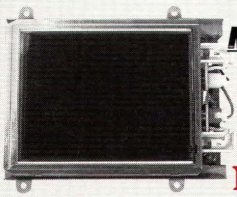

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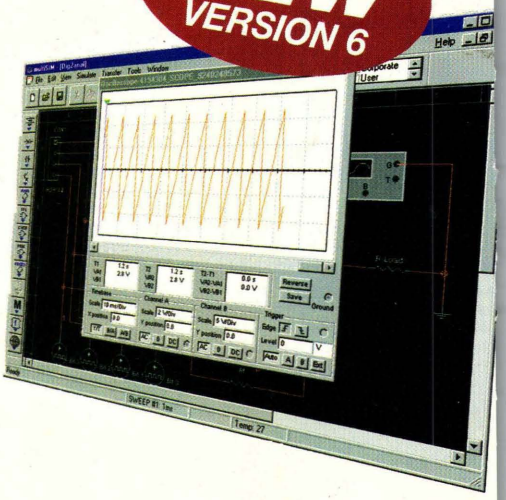

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